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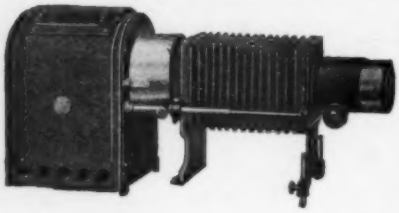

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SCHOOL SCIENCE AND MATHEMATICS

VOL. XVII, No. 9 DECEMBER, 1917 WHOLE No. 146

A PLAN FOR THE TEACHING OF GENERAL ZOOLOGY.[1]

By ROBERT W. HEGNER,

University of Michigan, Ann Arbor.

One of the most annoying difficulties that teachers of zoology have had to contend with in recent years is that of introducing new phases of the subject in such a way as to maintain a proper balance between the older subjects, such as anatomy and taxonomy, and the more recent sub-sciences, such as animal behavior and ecology.

During the past few years the writer has developed a plan for the study of animals in general or of any phylum, class, order, family, genus or species in particular that includes what seem to him to be the most important phases of modern zoology. The plan as it appears at the present time is applicable for the teaching of zoology in any grade in the elementary school, high school, or college, and has been carried out successfully with a university class of graduate students. It involves all of the subjects that anyone may wish to teach but allows the teacher unlimited selection both of those subjects that he thinks should be emphasized and of those that he considers it advisable to omit. Among the phases of zoology included are: field zoology, taxonomy, ecology, anatomy, comparative anatomy, histology, cytology, animal behavior or comparative psychology, neurology, general physiology, physiology of the organs, embryology, genetics, paleozoology, zoogeography.

The writer offers this plan simply as a convenient arrangement of materials. Throughout, one subject leads directly into the succeeding subject and hence results in the sustained interest of the students. The whole subject, in the first place, is divided into three subheads:

[1]Miss Grace F. Ellis has read the manuscript of this article and I wish to acknowledge in this place her valuable criticisms.

I. How animals maintain themselves in their environment.
II. How races of animals are maintained.
III. The relations of animals to man.

The first deals with adults only and the second with stages in their reproduction. Each subhead is divided into topics which are arranged in such a way as to lead from one to the other without perceptible breaks. An outline of the plan is as follows:

I. How Animals Maintain Themselves in Their Environment:

1. Recognition. Usually the first question that one asks on seeing an animal for the first time is, "What is it?" The characteristics of the animal or group of animals being studied that make its recognition possible in the field or laboratory are here determined. The position in the animal series and relations to other animals may be pointed out. This leads to a study of the local fauna and to the subject of taxonomy. Faunistic studies may easily be broadened so as to embrace the entire fields of zoogeography and paleozoology.

2. Habitat. The second question often is, "Where does it live?" It is convenient to separate the possible animal habitat into four groups: (1) fresh water, (2) marine, (3) terrestrial and (4) parasitic. Each of these may in turn be subdivided almost *ad infinitum*. For example, Shelford in his book on Animal Communities in Temperate America considers among others the following fresh water habitats; (1) streams, (2) large lakes, and (3) lake ponds. Each of these is subdivided into more restricted habitats. For example, the streams are separated into intermittent streams, permanent streams, and creeks and rivers. Each of these is again subdivided, e. g., there are recognized in the intermittent stream communities, intermittent rapid consocies, intermittent pool consocies and permanent pool or horned dace associations. Each of these could undoubtably be subdivided again and again. Any other of the larger habitats on the earth's surface could be treated in a similar fashion. Each of these habitats is characterized by certain physical factors and the animals living in them may at some time during their life history be subjected to these physical factors as well as to biological factors, i. e., the plants and other animals living in the habitat.

Such topics as polymorphism and symbiosis may be introduced under the heading of habitat, since these phenomena concern the relations of individuals of one species or of different

species to each other. The biology of the willow cone gall is one of the best subjects I know of for illustrating the complex relations that exist between plants and animals and between various species of animals. (See the paper by Heindel in the *American Naturalist* for 1915, Vol. 39.)

3. Protection. Before an animal can exist in its habitat it must have some means of protecting itself from the competitors and enemies with which it is constantly struggling. Animals are also obliged to protect themselves from numerous physical agents. Some of the more common means of protection are as follows:

(1) Resemblance to surroundings, either in shape or color. For example, the walking stick among the twigs of a tree and the garter snake in the grass.
(2) Armature, such as the shell of the mussel and the exoskeleton of the crayfish. At this point the study of the external or internal skeleton is in order.
(3) Escape by locomotion. Locomotor organs from pseudopodia and cilia to fins and wings may properly be discussed here.
(4) Weapons of defense, such as the stinging cells of coelenterates, the ink of the squid, and the jaws, claws, etc., of other animals. These may also be weapons of offense.
(5) Secretions or excretions. Distasteful substances that render the animal inedible, as in the monarch butterfly, or odorous secretions like that of the skunk, which repel what might otherwise be serious enemies.
(6) Ability to regenerate. Many forms like the fresh water flatworms and marine sponges are subjected to violent physical agents that would destroy vast numbers of individuals if it were not for the power of regeneration.

4. Awareness of Surroundings. Some method of determining the nature of the surroundings is necessary before an animal can locate its optimum habitat, recognize its enemies and find food. Here may be included as much material on animal behavior, sense organs, and the nervous systems as seems desirable.

5. Motion and Locomotion. The stimulation of sense organs usually results in motion or locomotion that is beneficial to the animal. Being aware of one's surroundings would be of little value if it were not possible to move out of harm's way and into a suitable environment. The discovery of the proper habitat; the finding of food; the distribution of the species; and many other activities depend upon the animal's power of motion and locomotion. Here is a good place to discuss the origin of the nervous and muscular systems and the structure of the latter.

6. Nutrition. After an animal has moved into a suitable habitat, its sense organs and powers of motion and locomotion enable it to find its food. The following topics may be included under the head of nutrition:

(1) Nature of the food. Animals and plants compared; holozoic as in most animals, or holophytic as in Euglena and most plants.
(2) Capture of the food. Organs of prehension, such as the tongue of the toad and the pinchers of the crayfish.
(3) Ingestion. The activities of pseudopodia and cilia and the structure and actions of the mouth parts, teeth, etc.
(4) Digestion. This involves a study of the digestive tract (in higher animals) and its appendages.
(5) Egestion. The extrusion of undigested material.

7. Circulation. After the food is digested, there must be some method of transporting it from the organs of digestion to other parts of the body. Even in single cells, like Ameba and Paramecium, the transportation of food is necessary. A distinct circulatory system has in the more complex animals superseded the simple flowing of the protoplasm or the more general gastrovascular system of the lower invertebrates. As much time as seems advisable may be devoted to the study of the blood, blood vessels and activities of circulation.

8. Respiration. The blood carries not only food material but in most animals it also transports oxygen and carbon dioxide. We may take up the subject of respiration under two heads: (1) external respiration, and (2) internal respiration. Under the first head we may determine how oxygen is taken into the body and carbon dioxide is given off. Internal respiration may be defined as the oxidation processes in the tissues. This subject may serve to introduce the phenomena of metabolism.

9. Secretion and Excretion. The processes of metabolism result in the production of waste materials that must be excreted or they will poison the individual. Other substances are formed by the cells of the body but these are of value and are known as secretions. Under this heading there may be included studies of the morphology of the excretory system and of glands and the effects of excretory products and of secretions, thus leading to the elucidation of the important subject of hormones and their action and of the nitrogen cycle.

II. How Races of Animals are Maintained.

This topic may include such subjects as reproduction, embryology, growth, metamorphosis, senescence and genetics. Children and men and women should be more familiar than they are with the facts regarding sex, reproduction, and development, and no better solution of the problem now offers itself than the study of these subjects as a regular part of the courses in zoology, using the lower animals as material. The outline of this section as well as that on the first section should be simplified or amplified according to the grade of students who are using it.

Reproduction:

1. A fundamental property of protoplasm.
2. Powers of reproduction of animals.
3. Checks to reproduction—the struggle for existence.
4. Asexual reproduction:
   a. Definition. Reproduction without the intervention of sex cells.
   b. Cell division. All reproduction a form of cell division.
   c. Fission in Protozoa, segmented annelids, flatworms and in the embryos of the jellyfish, Ameba and in man (identical twins).
   d. Sporulation in Ameba, Monocystis and Plasmodium.
   e. Budding in Protozoa, Hydra, sponges, and in the embryonic development of the armadillo and certain parasitic Hymenoptera.
   f. Gemmulation in sponges.
   g. Regeneration in Planaria, Hydra, and frog tadpoles.
5. Sexual reproduction:
   a. Definition. Reproduction by means of sex cells.
   b. The female sex cell—the egg.
   c. The male sex cell—the sperm.
   d. The sexual organs and accessory parts of dioecious animals. The typical condition occurs in the queens and drones of the honey bee.
   e. Hermaphroditism. This is the normal condition in Planaria, the earthworm, certain snails, etc.
   f. Oviparity and viviparity. The former occurs in the birds, duckbill, most insects, frogs, etc.; the latter in the plant lice, the garter snakes, turtles and most mammals, etc.
6. Chromosomes and their importance in heredity.
7. Fertilization.
8. Embryonic development as illustrated by the development of the frog's egg.

Throughout this section it should be noted that the eggs, larvae and immature stages of animals are subjected to environmental factors which they must be able to withstand just as are the adult individuals. Frequently adults are able to exist in a particular habitat but the race is unable to maintain itself there because of the inability of the eggs or young to overcome the physical and biological factors of their environment.

Those who are teaching a more advanced class of students may be able to use part or all of the following outline in addition to that already given in this section:

A. The Germ-Cell Cycle in animals. The idea (in this part of the outline) is to trace the history of the germ cells from one generation to the next, beginning with the fertilized egg.
   1. General facts of ontogeny.
   2. Cell lineage.
   3. The organization of the egg.
   4. The segregation of the germ cells during early embryonic development.
   5. The multiplication of the primordial germ cells.
   6. The differentiation of the oogonia into oocytes and nurse cells.
   7. Period of growth.
   8. Maturation (not including a consideration of the chromosomes).

9. Fertilization (general account).

B. The Chromosome Cycle in Animals.
   1. Behavior of chromatin during ordinary mitosis.
   2. Constancy in number and size of chromosomes in individuals of a species. (The sex chromosomes may be considered later.)
   3. Genetic continuity of chromosomes.
   4. Chromosomes during maturation. Synapsis, reduction and distribution of chromosomes after reduction.
   5. Chromosomes during fertilization. The potentialities of the offspring depend on the kinds of chromosomes contained in the fertilized egg.
   6. Uniqueness of individuals explained by the chromosome hypothesis.

C. Chromosomes and Sex.
   1. Sex-limited inheritance.
   2. Sex chromosomes and their behavior.
   3. The chromosomes of hermaphrodites.
   4. The chromosomes of parthenogenetic animals.

D. Sex-linked Inheritance.
   1. Mendelism. Unit characters, factors, segregation, etc.
   2. Linkage.
   3. Sex linkage.
   4. Crossing over.
   5. The location of factors in chromosomes.

E. Sex Determination.
   1. At the time of fertilization.
   2. Before fertilization.
   3. After fertilization.

F. Organic Evolution and the Factorial Hypothesis.

G. The Life Cycles of Animals.
   1. Distinction between life cycles and life histories.
   2. Closed and open life cycles.
   3. Polymorphism.
   4. Metagenesis.
   5. Alternation of bisexual and parthenogenetic generations.

III. The Relation of Animals to Man.

The economic phases of zoology have of recent years come into more prominence than ever before and must be considered in most courses. By economic zoology I mean not only the commercial value of animals but also the indirect benefits and injuries due to the activities of wild species, such as insectivorous birds and vegetable eating insects. It seems advisable to point out the relations of the groups of animals to man as each group is being studied, but the subject may well occupy a place by itself after a general knowledge of the phyla has been obtained. It also seems best to devote the larger part of the time that can be devoted to economic study to those groups that occur or are of most importance in the particular region where the subject is being taught. For example, in the Great Lakes region the artificial propagation of the lake trout and whitefish should command more attention than that of the salmon and flounder. The following plan presents an outline of materials arranged according to the evolutionary series:

1. Protozoa:
   a. Pathogenic Protozoa, such as the malaria fever parasite.
   b. Protozoa that cause trouble in drinking water.
   c. Protozoa that form strata of the earth's crust by the deposition of calcareous and siliceous shells at the bottom of bodies of water.
2. Porifera.
   a. Commercial value of sponges and sponge growing for market.
3. Coelenterata.
   a. Corals, coral islands and coral reefs.
4. Platyhelminthes.
   a. Trematodes, parasitic in man and domesticated animals.
   b. Cestodes, parasitic in man and domesticated animals.
5. Nemathelminthes.
   a. Human parasites, such as the hookworm.
   b. Parasites of domesticated animals.
6. Echinodermata.
   a. Injuries done by starfishes in oyster beds.
7. Annelida.
   a. The influence of the earthworm on the formation of vegetable mould.
   b. The rise and fall of the medicinal leech.
8. Mollusca.
   a. Mollusks as food for man, such as snails, oysters, clams, etc.
   b. Mollusks as food for other animals that are used by man.
   c. Injurious mollusks, such as the shipworm, the oyster drill and the octopus.
9. Arthropoda.
   a. Crustacea as food for man, such as the lobster, crayfish, and shrimp.
   b. Crustacea as food for fish and other aquatic animals.
   c. Insects as food for man.
   d. Insects of the household, of man, of domesticated animals, of fields, of gardens, of orchards, of forests, etc.
   e. Insects that pollinize flowers, or produce honey, wax, silk, etc.
   f. Predaceous and parasitic insects.
   g. Insects that transmit disease germs.
   h. Poisonous arachnids.
   i. Arachnids vs. insects.
10. Vertebrata.
    A. Fish.
       a. Commercial value.
       b. Food and game fishes.
       c. Fish culture.
       d. Conservation of fishes.
    B. Amphibia.
       a. Importance as destroyers of insects.
       b. Value as food for man.
       c. Value as material for physiological investigation.
    C. Reptilia.
       a. As food for man.
       b. Poisonous snakes.
       c. Commercial value.
    D. Aves.
       a. Commercial value.
       b. Food and game birds.
       c. Bird conservation, including protection and propagation.
       d. Insectivorous birds.
       e. Birds of prey.
    E. Mammalia.
       a. Commercial value.

b. Food and game mammals.
c. Predaceous mammals.
d. Insectivorous mammals.
e. Gnawing mammals.
f. Fur bearers.
g. Conservation of mammals.

The above plan, if carried out conscientiously, will be found to give continuity to the subject matter, to keep the interest of the students, and to allow the teacher to give as little or as much of any phase of zoology as he may wish. The textbooks now on the market do not follow exactly the plan here outlined but they contain much of the material and may therefore be used as reference works. Other materials may be obtained from large reference works or from periodical literature—sources of information that should be at the command of every student—and many questions may even be determined by actual observations of the living animals or of preserved specimens. Students who follow such an outline become more observing and systematic, and have their interest in and powers of investigation highly developed.

It might be well to emphasize the fact to the student that the study is being pursued according to the scientific method. Each section presents in reality a problem to be solved, involving many minor problems. Each of these requires the collection and confirmation of facts, and the discovery of new facts. These facts must then be arranged and classified and a conclusion (scientific law) reached that will bind together the mass of facts into a unified hole. No opportunity should be neglected to point out the value of this method as a training of the mind for the activities of life regardless of the importance of the facts learned.

The laboratory work for any particular class of students will of course have to be determined by the facilities of the laboratory, the proximity to collecting grounds, the time available, and other factors. Since most of the readers of this magazine are teachers in secondary schools, I shall attempt to give a tentative plan for one group of animals that may be used in high schools. The first animals studied in the autumn are usually the insects. Laboratory and field work for this class should be arranged as follows:

I. How Insects Maintain Themselves in Their Environment.

1. Study those external features of the grasshopper that are characteristic of insects in general.
2. Collect insects in the field. This should be accompanied

by remarks on methods of collecting. An attempt should be made to obtain insects from as many different habitats as possible and representatives of the principal orders. The conditions under which the insects exist should be determined for each habitat. Information can be acquired in the field that will be useful in the study of protection, awareness of surroundings, motion and locomotion, nutrition, reproduction, growth, metamorphosis, and economic relations. Data on these subjects should be recorded in field notebooks and should be classified. Living specimens should be brought into the laboratory and placed in suitable aquaria or terraria for further study.

3. The preserved specimens should be mounted and classified.

4. Observations on resemblances to surroundings, armature, locomotion and weapons of defense should be made on both living and preserved specimens and these data may be discussed and classified during a class period.

5. Observations on the reactions of the living specimens to various stimuli should be undertaken in order to learn something regarding the animal's awareness of surroundings. Data from the field notebooks will add to these observations. This work should be supplemented with an examination of the structure of the eyes, and other sense organs.

6. The reactions to stimuli involve a study of motion and locomotion as observed both in the field and in the vivaria. The observation of the organs of locomotion of specimens from various habitats furnishes one of the most inspiring exercises in the whole realm of biology, that of the adaptation of animals to life in or on the waters, in the air, on or under the ground, and in or on other animals.

7. The subject of nutrition as outlined above can be followed in the field and laboratory with studies on the nature of the food, organs of offense and of prehension, and methods of ingestion from observations of living material. Preserved specimens afford material for the study of the different types of mouth parts and of the alimentary canal.

8. Circulation can best be observed in living insects that are transparent, particularly certain larvae.

9. The movements of respiration can be seen in living specimens and the respiratory system can be made out in certain living insects, especially aquatic larvae. Such a study is more satis-

factory than work on preserved material, although the structure of the tracheae should be determined from the latter.

10. Preserved insects afford material for the study of the excretory system—the malpighian tubules—and of the organs and products of secretion, particularly the glands and the exoskeleton.

II. How Races of Insects are Maintained.

1. The differences between the males and females as regards external features may be determined, using the grasshopper for the study of genitalia, moths for sexual differences in antennae, etc. An observation hive of honey bees is very useful for the study of sex differences and division of labor among the members of a colony.

2. The internal organs of reproduction may be dissected out and examined. Stages in the growth of the egg up to the time of disposition may be observed with ease in the ovarian tubules of aquatic beetles and spermatozon may be obtained from the testes. Freshly killed specimens are best for this work.

3. Stages in the development of the egg may be studied with the aid of prepared slides if considered desirable. Late stages in embryology may be obtained during the winter in the eggs of the grasshopper (Xiphidium) that oviposits among the scales of the willow cone gall. The embryo can be seen through the egg shell in these eggs after being killed in boiling water.

4. The two types of metamorphosis can be observed in material collected by the students. All stages in the direct metamorphosis of the grasshopper may be obtained early in the autumn. Indirect metamorphosis may be watched in silkworms that are kept in the laboratory. This material is also valuable for observing the spinning of cocoons, etc.

5. The phenomena of parthenogenesis and viviparity are very easily demonstrated in plant lice. I have found chrysanthemum plants particularly favorable for this work. A single plant louse placed on a small chrysanthemum plant beneath an enclosed lantern chimney will thrive and give birth to numerous young.

III. The Relations of Insects to Man.

1. Insects that pollenize flowers. Some of the most wonderful examples of structural adaptation are those exhibited by the legs of the honey bee that are used for gathering pollen.

2. Insects that produce honey, wax and silk. Living silkworms may be kept in the laboratory and observations made of the various stages in their life history, especially the cocoon-spinning operations. The activities of the honey bee should

be watched in an observation hive. The organs of the honey bee used in honey and wax making may be studied with the microscope. These are the mouth parts, forward portion of the alimentary canal, wax glands, and structures on the legs.

3. Insects that transmit disease germs. The house fly is the best example of a passive carrier of germs, especially those of typhoid fever. The structures of the proboscis and legs which make them peculiarly fitted for the transference of germs should be studied. The mosquito is the best example of an active carrier. Its mouth parts, alimentary canal and salivary glands may be demonstrated. Practical work for the eradication of both house flies and mosquitoes may be carried on successfully, as has been proved by campaigners in many communities.

4. Insects of the household. Students should become acquainted with the more common household insects, such as the cockroach, red ant, cheese skipper, meal worm, bedbug, buffalo moth, and clothes moth, and be given practical instruction and demonstration for their control.

5. Insects of man. Lice and fleas should be dealt with in a similar manner.

6. Insects of domestic animals. The cat and dog flea, chicken lice, horse flies, bot flies, etc., should be demonstrated in the same way.

7. Insects injurious to vegetation. This subject involves a study of methods of feeding and the structures concerned, demonstrations of apparatus for control of insects with biting and sucking mouth parts, and the compilation of data obtained from field observations and from government reports and reference books.

8. Predaceous and parasitic insects. Among the most easily collected predaceous insects are the ground beetles, which are abundant under boards or stones in fields,. In this connection the remarkable control of the fluted scale by the Vedalia beetle in California should be described and also the attempts that are now being made to destroy the gypsy and brown-tailed moths in the New England States with the aid of the Calosoma beetle. Parasitic insects may usually be obtained from the cocoons of moths. If a number of cocoons are collected in the fall and kept in glass containers in the laboratory, some of them are almost certain to be parasitized and the parasites will emerge during the winter. A description of the work being done by the Gypsy Moth Parasite Laboratory at Melrose Highlands, Mass., will be of interest here.

AN EXPLANATION OF THE PRACTICAL SIDE OF BAKING POWDER MANUFACTURE—ITS CHEMISTRY—ITS ARITHMETIC.

By Jessie F. Caplin,

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Baking powder is an artificial mixture of chemicals capable of producing carbon dioxide, and suitable for use in the making of cake, biscuits, muffins, etc., where the slower acting yeast is not desirable. The source of the carbon dioxide gas which puffs up the bread and produces the leavening action is usually sodium bicarbonate, or baking soda.

Types of Baking Powders:

1. Cream of Tartar.
2. Phosphate.
3. Alum.
4. Phosphate-Alum.
5. Ammonia.

The strength of baking powders is measured in terms of CO_2 that is available by the action of water and baking temperatures. The difference between the total CO_2 (determined and released by excess added acid) and the available CO_2 is called the residual CO_2. If a powder is perfectly balanced, the residual CO_2 will be very low, but practical experience has shown it to be more desirable to have about 1-2 per cent excess $NaHCO_3$ than to have the acid constituents in excess.

It will yield half its carbon dioxide upon simply heating, but the process leaves a residue of sodium carbonate which imparts a bitter taste and yellow color to the product, and also hinders digestion by neutralizing the acid of the gastric juice. All of these difficulties can be removed by adding to the soda a substance possessing acid properties—all of the carbon dioxide is liberated and the objectionable sodium carbonate is transformed into other salts. Commercial baking powders use for their acid ingredient cream of tartar or calcium hydrogen phosphate or "alum."

Baking powders are measured in terms of sodium bicarbonate, and are all planned to yield 14 per cent of carbon dioxide, though by deterioration this may decrease to not less than 10 per cent. Corn starch is always added to keep the ingredients dry and prevent them from interacting before they are actually used. For the same reason, a tin can is used for a container, and the warning to "keep tightly closed" is added.

Baking soda is approximately 50 per cent carbon dioxide, so in order to make a hundred pound batch yielding 14 per cent carbon dioxide, one must use twenty-eight pounds of sodium bicarbonate. To interact with this are required sixty-two pounds of cream of tartar. The final formula therefore is: 28 pounds sodium bicarbonate; 62 pounds cream of tartar; 10 pounds corn starch. Cream of tartar is the expensive ingredient.

Tartaric acid makes the mixture act more rapidly at the start. It has a neutralizing power with respect to sodium bicarbonate of 114; this means that 100 pounds of tartaric acid neutralize 114 pounds of sodium bicarbonate. It is common to use three pounds of tartaric acid per hundred, then figure the cream of tartar. For a four hundred pound batch the formula becomes: 112 pounds sodium bicarbonate; 12 pounds tartaric acid; 219 pounds cream of tartar; 57 pounds corn starch. The arithmetic involved is interesting, and simple enough to be worked out by any high school student of chemistry.

The "alum" of today is a mechanical mixture of sodium sulphate and aluminum sulphate. Its trade name is S. A. S. (sodium aluminum sulphate). The two sulphates are mixed in such a way that it has a neutralizing power with respect to sodium bicarbonate of 100. Therefore less chemicals are required, a smaller quantity of new salts are formed. The formula would be: 28 pounds sodium bicarbonate; 28 pounds S. A. S.; 44 pounds corn starch. Alum is the cheapest neutralizing agent, and the Referee Board has found that baking powders containing alum are quite as harmless as any other baking powders.

In a phosphate baking powder, it is common to mix calcium hydrogen phosphate with enough starch to give it a neutralizing power of 45. That is, 100 pounds of it will neutralize 45 pounds of sodium bicarbonate.

But 45 is the strength of cream of tartar, so calcium hydrogen phosphate can be substituted in a cream of tartar formula. Such mixtures keep poorly, and all ingredients must be redried, and should be in the form of granules rather than powdered.

Tartaric acid, phosphate and alum give a progressive action. Bake stuffs made with them do not fall as rapidly as when cream of tartar is used, hence are more satisfactory for inexperienced or careless cooks. In comparing baking powders one should consider:

(a) Amount and character of chemical residue.

(b) Which goes farthest.

(c) Cost.
(d) Character of the leavening action.
(e) Keeping qualities.

The phosphate alum type is the most popular type. The action of the phosphate in the cold is sufficiently rapid and progressive to prepare the bake stuff for the oven and the slow solubility of the alum keeps the CO_2 evolving until the dough is set by the heat. The tendency in cream of tartar powders is that the powder gives off too great a proportion of its leavening power in first part of the operations so that any disturbances or a poor, slow oven may bring bad results. Phosphate alum powders protect the careless or extra busy cook so to speak. A great many good cooks stick to cream of tartar powders because they have always gotten good results. They don't consider that they (being extra good and careful cooks who plan their work and have their ovens always just right) are exceptions to the rank and file of housewives and domestics who do not observe the rules of good cooking as rigidly.

Ammonium bicarbonate leaves no residue at all and gives the leavening action of ammonia as well as carbon dioxide by the simple application of heat. It is used for such things as cookies but not for moist baked things like biscuits where the ammonia would still be held.

Magnesium carbonate is fluffy, adds bulk, but takes twice as much acid. Egg albumen is sometimes added because it makes a favorable impression when used in a demonstration.

In the household, sour milk is often used with the baking soda. It is evident that the neutralizing power of the milk will vary, depending on how sour it is. Hence, in any recipe calling for sour milk, it is better to vary the proportion of sour milk depending on the quality. Vice versa, if baking soda is added to reduce acidity, as in making tomato soup, or with molasses in gingerbread, the soda should be added very gradually as long as an action is apparent. In some households, cream of tartar and soda are bought separately and mixed—the proportion, as has been stated, is approximately two to one. These numbers are easily remembered if one counts cream of tartar as two words and soda as one. If one looks back at the formula already given for the cream of tartar baking powder, it will be seen that the proportion of corn starch added is very small, so that one spoonful of mixture of these two ingredients may be substituted for one spoonful of baking powder in any recipe.

THE PLACE AND VALUE OF GENERAL SCIENCE.[1]

By E. A. STEWART,
Duluth, Minn.

This subject has created considerable discussion during the last six years, and I am one of those who wish to help out the solution, if it is possible to do so. Nearly everyone who has written on this subject has his own particular course in mind when he speaks of general science. I shall, therefore, state my idea of what a general science course should be before I proceed with this discussion.

I do not believe in giving a course that is composed of the elements of the different sciences, which kind of a course has been correctly called a "hodgepodge." I believe that the first part of the course must deal largely with physical and chemical phenomena. The course that I have outlined and have used for the past six years starts with the study of the atmosphere; takes up a study of its origin, composition, uses and the uses and production of its component parts. We then take up a more detailed study of water, in which we treat the physics and chemistry of the subject first, and then lead over into a detailed study of meteorology, then erosion and weathering. The reactions of water on plant and animal life are taken up next and finally we take up a study of the forces and forms of energy that are manifested in the previous work.

The greatest difficulty that I have found in planning such a course lies in the elimination of material. One criterion that helps in this elimination is, "All topics that lead only to a study of one particular higher science, that are not common to two or more sciences, and that have no direct relation to the students' life should be eliminated." This statement should not be taken to mean that the science work will explain only the phenomena that the student knows of, but we must explain some phenomena that he will encounter when informed of its existence, in order to enlarge the student's field of living.

You will notice that this outline of a course does not suggest such practical topics as heating, ventilation, digestion, sewage disposal, farm animals, soil physics, plant propagation, bacteria, etc. We have handled these topics for the past two years, but not in general science in the ninth year. Such practical topics as I have mentioned have been treated in the elementary science in the seventh and eighth grades, with the exception of those topics that are entirely of high school grade and are

[1]Given at the State Teachers' Association meeting at Duluth, Minn., February 23, 1917.

for special science. Such topics as bacteria, farm animals, soil physics, etc., are too technical and for the most part of local interest and should be handled in the separate science courses. A general science course that attempts to cover all of these practical topics cannot be a universal success, as these topics are not of universal interest.

I believe that the foregoing statements make clear the course that I have in mind during this discussion. I shall now take up the place of general science in the school curriculum. We need science in the freshman year in the high school, for it is better suited to the adolescent child than are the subjects of English, language or mathematics. These other subjects contain too much new material, and do not deal with life and nature, the two things that all boys and girls at this age are interested in. The memory work in mathematics and language is distasteful to the student and no one doubts that memory work is essential in these subjects. The English work, when correlated with science, from which it may draw thousands of topics for exposition and argument, will not be objectionable but highly desirable. On the other hand, if we teach technical English or English masterpieces, it then is objectionable for students of the adolescent age. The child at this age loves to think and to arrive at judgments that are entirely new to him. He likes science because of the opportunity offered to answer for himself the question "Why?" Professor Brown, in his book entitled, "The American High School," states, "The reason for things appeals to the child as never before. He is disposed to dislike memory work." We agree with Professor Barber when he says, "Abstractions, generalizations, and type studies are foreign and distasteful to the normal adolescent child."

Granting that most of us agree that science should be offered in the first year of the high school, I shall now take up the reasons to show that general science is more valuable here than any of the special sciences. I want to state that science teachers are not the only ones that believe a general course in a certain type of study is more valuable than a special course. Professor Karpinski, in an article on "Unified Mathematics" in the January 20 number of this year of "School and Society," argues for a course in general correlated mathematics. The Mathematics Club of Chicago gives as its recommendation for mathematics in the secondary schools the following: "At least one year of mathematics should be required of all secondary students.

It may be a general introduction to the field of mathematics."

I believe that general science is more valuable in the first year of the high school course for the following reasons:

First. It takes up the phenomena in a natural order. Nature is not physics, nature is not chemistry, it is not botany or zoology. Why, then, should we take out of nature a one-sided affair like physics and assert that it is more unified than a composite account of nature in all of its different aspects. How can a division of materials be again united into a more logical whole than they were when left to nature before being divided by man.

Second. General science is more valuable than a single science because any single science given at this stage of the development of the child must be more or less general, and it will not be a good general science course nor a good special science course. Professor Hessler says, "Each of these sciences leads the student off into special fields of knowledge; it requires certain antecedent knowledge; it also demands some maturity and grasp of technical distinctions that is beyond the ordinary child of twelve or fourteen years."

Third. General science eliminates waste. If this course is required of all students before they take the special sciences, as it should be, a great deal of material common to all of the course may be omitted from the special courses. I can omit eighty-three pages of work in Millikan and Gales textbook in physics when my students have taken general science. I can omit the equivalent of forty-three pages in the chemistry text that we are using. The general science course would eliminate the time taken to duplicate this work in the different courses. It is a well-known fact that students starting in physics who have had chemistry find the new subject easy, or as one boy said, "It is a cinch after having chemistry." The course in general science will also prevent such sad conditions as occurred in one chemistry class in which 20 per cent of the class had taken two years of science before taking chemistry, 53 per cent had taken one year, 7 per cent had one-half year, and 20 per cent had taken no previous science work. The entire 20 per cent that had not taken science failed in the course after the work had been held back for their benefit.

Fourth. General science creates more interest in the work than does a special science. This is shown by the result of the adoption of the course in many schools. In the Wichita (Kan.)

high school there was 23 per cent of the entire enrollment of the school enrolled in science during the year 1910-1911. The following year was the first year when general science was offered. During the year 1914-1915 there was 33 per cent of the total school enrollment taking courses in science. I believe that the result is significant. The whole course in general science is related to experience and, therefore, it is practical and interesting. As an example of interest, I shall recount an experience of my own. I have had classes who for days at a time went through the entire class period in almost complete forgetfulness of self and surroundings because of interest in some experiments that were to settle a previous discussion or an experiment that was to settle the correctness or falsity of a common belief. Students often crowd to the desk in silence to see the result of some experiment. If this does not develop self-elimination in discovering a truth, then no science course does. I admit that there are times in which this may be done in any special science course, but my experience with both kinds of courses shows that there are many more opportunities in a general science course.

Fifth. If a student drops out of science work after one year he is better prepared for a broader scientific training in the world and he has learned more practical facts that will be of use to him in living than he would have received in a special course. As this point is conceded by nearly every opponent of general science, I shall not argue it.

Sixth. General science makes better students. This may seem like a broad statement, but I believe that my experience as well as that of many others bears this out. Education in science is teaching one to think. A pupil of mine said, "I can get science because I can think it out but I can't remember the algebra." Just this week one student in general science said, "I like science because I can think out things for myself." The student will talk more in a general science course than in a special science course because he knows more about the subject to begin with and they are always eager to tell their experiences. In this way a teacher has an excellent chance to teach better English. The student, then, not only uses better English but he understands more fully the material that he reads. We showed this in our experiments at Wichita, as reported by Principal I. M. Allen in an article on "Some Experiments in High School Teaching" in the January, 1914, number

of the *School Review*. Briefly, the experiment was this. Six freshman students who had taken one-half year of general science were picked at random by another person than their teacher. These students were placed for one day in a class in physiology consisting of twenty-nine Juniors and Seniors, who had not taken general science. A discussion and reading of the topic "The Chemistry of Respiration" (Conn & Buddington, pp. 200-205) was taken up in class. This was work much in advance of what the class was taking. The students were given a test on assimilation questions. The results were very significant. The grades of the Freshmen averaged 90 per cent, of the six best Juniors and Seniors, 87 per cent, and of the remaining twenty-three, 73.6 per cent. This is only one of many experiments tried in other subjects, such as English and mathematics, that point to the conclusion that general science does train students to think better than does a single science.

I will now refer to some of the objections that are made to a general science course. One objection is that general science is a hodgepodge. Professor Coulter, in the article "The Mission of Science" printed in the *School Review* for January, 1915, says, "A mosaic made up of fragments of information breaks up all natural connections and forbids the development of those ideas which relate and hold facts." The meaning of this objection is made plainer by his implied comparison of the teaching of the commonest words from all the languages and calling it language. This objection is not pertinent as it applies to the earlier attempts at a science course and not to the type that I am advocating. The general science could not be more of a mosaic than the present physics course in which the material jumps abruptly from mechanics to heat, from heat to magnetism, etc.

The main objection to this course seems to be that given by the specialists. They appear to be afraid that if general science is put in, that their particular specialty will be put out. Professor Millikan in a talk with me said, "My boy needs to take his three units of English, five units at least in foreign language, two in mathematics and one in history, and at least one in handwork. This leaves only three for science. If he takes general science which one will he leave out?" I am of the opinion that if these courses are reconstructed, no one of the special sciences will need to be dropped out. I can give a student a half year's work in general science and then cover more ma-

terial of the three sciences in the next two and a half years than I can cover in three years without the general science. To do this will require the reconstruction of our science courses; make them progressive and require the student to take the simplest first and the most difficult last, as we do in English, language, and mathematics. This sequence of science subjects would also aid in eliminating the falling off in the number of students that are taking science.

In the discussion of the last objection I have stated somewhat the position that I believe the general science should occupy. Before going into this place of general science in detail, I wish to state that the methods advocated to solve the question proposed by Professor Millikan, and as stated by him in an article on "Elimination of Waste in the Teaching of High School Science," printed in the March number, 1916, of SCHOOL SCIENCE AND MATHEMATICS, seem to me to be impracticable. Professor Millikan proposes that we give the three courses in parallel. The courses would aid in understanding each other, but it would certainly be far from logical work from day to day. Granting that this method is desirable, can it be carried out in America as it has been in European countries? I believe that it cannot be done. Our large number of subjects in the curricula, our freedom of choice in electives, would not make it possible to use different teachers for the various sciences, and if one teacher handled all the science work, as they attempt to do in the smaller schools, it would seriously cripple our science work. Perhaps you say, "Thousands of teachers are teaching those three sciences today." Yes, they are, and that is where most of the poor teaching is done. I have taught all three together and I have taught one alone. The one that was taught alone was handled with three times the efficiency that the three were when handled together. Imagine just for a moment the state of mind of a teacher who is handling all three years of science in a small high school. He would need material for three different parts of physics, three different parts of chemistry, and three different parts of biology all in one week, or all in three weeks, if we were to use the weekly alternation.

Another solution that has been proposed is to have three years of general science. I am sure that the equipment of laboratories in large schools and the securing of sufficiently trained teachers are objections that will preclude the formation of such courses. I agree with Dr. Coulter when he says, "A division

of the materials of science seems necessary, therefore, not only to secure competent teaching, which is a practical reason, but also to secure a point of view that represents permanent possession, which is the essential feature of education."

Some of the workers on this subject have proposed that we use project science for general science. I propose that we give project science or the practical applications of science in the seventh and eighth years, or what is called the first two years of the Junior High School. We have been trying this plan for the past two years and it has been fairly successful. The general science should be a truly general science course, one that is general to all the sciences and not a course in the elements of the various sciences.

The type of general science course that I am advocating may be compressed into a half year's course or it may be stretched out for a full year's work. I am in favor of a course lasting for a half year, and then take up one of the special sciences. If a school wishes to give a full year's work in each of the three other regular sciences, then they may do as we have been doing, that is, give some course that is particularly adapted for the location during the remaining half of the Freshman year. We are giving a course in geology because of our favored location for such work.

If we are going to formulate a progressive science course and allow the students to take the subjects only in the order offered, then we cannot demand more than three years' time for the work in science. Other elective courses, such as physiology, astronomy, and physiography, may be offered and given in parallel with the courses in the regular course. I am of the opinion that we can give general science, biology, chemistry and physics in the order named in three years' time.

LOUISIANA AND TEXAS FURNISH MOST OF SULPHUR.

More than 98 per cent of the native sulphur now produced in the United States comes from deposits in Louisiana and Texas, according to Philip S. Smith, of the United States Geological Survey, Department of the Interior, but deposits of sulphur that have been or might be productive occur in Wyoming, Nevada, Utah, California, Colorado, Oregon, and Alaska.

Louisiana and Texas apparently produce enough sulphur to supply even an extraordinary demand, for the combined output of these two States, although the production has not been vigorously pushed, has so greatly exceeded the amount sold that large stocks of sulphur have been accumulated.

PROOFS OF THE ADDITION AND SUBTRACTION FORMULAS BY MEANS OF PTOLEMY'S THEOREM.

By Albert Babbitt,
University of Nebraska, Lincoln.

Ptolemy's theorem states that "*the rectangle contained by the diagonals of a quadrilateral figure inscribed in a circle is equal to both the rectangles contained by its opposite sides.*"[1] By means of this theorem and the Law of Sines, the addition and subtraction formulas of trigonometry can be easily derived.

I. $\sin(\alpha+\beta) = \sin\alpha\cos\beta+\cos\alpha\sin\beta$.

Proof. Draw the diameter AB, construct at the point A

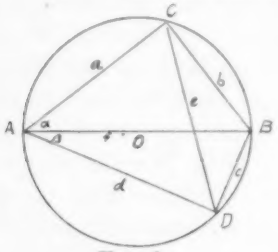


Fig. 1

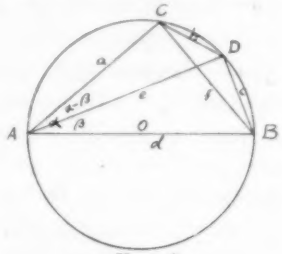


Fig. 2

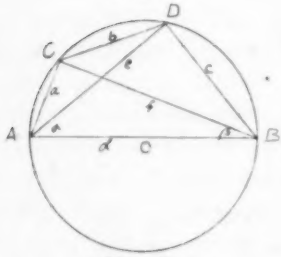


Fig. 3

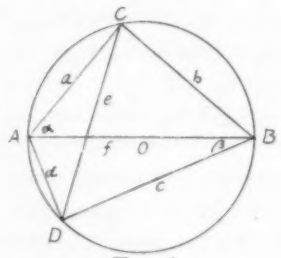


Fig. 4

$\angle$s α and β and complete the construction as shown in Fig. I.

From Ptolemy's theorem it follows that

$$ef = ac+bd.$$

Dividing through by f^2, we get

$$\frac{e}{f} = \frac{ac}{f^2} + \frac{bd}{f^2}, \text{ or}$$

$$\frac{e}{f} = \frac{a}{f}\cdot\frac{c}{f} + \frac{b}{f}\cdot\frac{d}{f}. \qquad (1)$$

[1] Cajori, *A History of Mathematics* (1909), p. 57.
"It is believed that the elegant theorem generally known as Ptolemy's Theorem is due to Hipparchus and was copied from him by Ptolemy." Ball, *A Short History of Mathematics* (1909), p. 88.

From the Law of Sines[2] it follows that

$$\frac{e}{f} = \sin(\alpha+\beta).$$

Also from the definitions of the trigonometric functions,

$$\frac{a}{f} = \cos\alpha.$$

$$\frac{c}{f} = \sin\beta.$$

$$\frac{b}{f} = \sin\alpha.$$

$$\frac{d}{f} = \cos\beta.$$

Hence, by substitution in (1) we get

$$\sin(\alpha+\beta) = \cos\alpha\sin\beta+\sin\alpha\cos\beta.$$

II. $\sin(\alpha-\beta) = \sin\alpha\cos\beta-\cos\alpha\sin\beta.$

Proof. Perform the constructions shown in Fig. 2.

Now,

$$ef = ac+bd \text{ (Ptolemy's Theorem).}$$

Dividing through by d^2, we get

$$\frac{e}{d}\,\frac{f}{d} = \frac{a}{d}\,\frac{c}{d}+\frac{b}{d}. \tag{1}$$

It is easily seen that

$$\frac{e}{d} = \cos\beta. \qquad \frac{c}{d} = \sin\beta, \text{ and}$$

$$\frac{f}{d} = \sin\alpha. \qquad \frac{b}{d} = \sin(\alpha-\beta)$$

$$\frac{a}{d} = \cos\alpha.$$

Substituting into (1) and transposing we have

[2] $a/\sin\alpha = b/\sin\beta = c/\sin\gamma = 2r$, or $a/2r = \sin\alpha$; $b/2r = \sin\beta$; $c/2r = \sin\gamma$.

$$\sin(\alpha-\beta) = \sin\alpha\cos\beta-\cos\alpha\sin\beta.$$

III. $\cos(\alpha+\beta) = \cos\alpha\cos\beta-\sin\alpha\sin\beta.$

Proof. Construct the angles α and β at the points A and B respectively and complete the construction as shown in Fig. 3.

Now,

$$ef = ac+bd \quad \text{(Ptolemy's Theorem)},$$

$$\frac{e}{d}\cdot\frac{f}{d} = \frac{a}{d}\cdot\frac{c}{d}+\frac{b}{d},$$

$$\cos\alpha\cos\beta = \sin\beta\sin\alpha+\sin\text{CBD}. \tag{1}$$

But, $\sin\angle\text{CBD} = \sin[90^\circ-(\alpha+\beta)] = \cos(\alpha+\beta)$

Hence, $\cos\alpha\cos\beta = \sin\beta\sin\alpha+\cos(\alpha+\beta)$, or

$$\cos(\alpha+\beta) = \cos\alpha\cos\beta-\sin\alpha\sin\beta.$$

IV. $\cos(\alpha-\beta) = \cos\alpha\cos\beta+\sin\alpha\sin\beta.$

Proof. Perform the constructions as shown in Fig. 4.

Now, $ef = ac+bd.$ (Ptolemy's Theorem),

$$\frac{e}{f} = \frac{a}{f}\cdot\frac{c}{f}+\frac{b}{f}\cdot\frac{d}{f}. \tag{1}$$

But, $$\frac{e}{f} = \sin\angle\text{CBD} = \sin(\text{CBA}+\beta) \quad \text{(Law of Sines)}$$

and, $\angle\text{CBA} = 90^\circ-\alpha.$

Hence, $$\frac{e}{f} = \sin(90^\circ-\alpha+\beta) = \cos(\alpha-\beta)$$

Since, $\dfrac{a}{f} = \cos\alpha,$ $\dfrac{c}{f} = \cos\beta,$

$\dfrac{b}{f} = \sin\alpha,$ $\dfrac{d}{f} = \sin\beta,$ we have

from (1)

$$\cos(\alpha-\beta) = \cos\alpha\cos\beta+\sin\alpha\sin\beta.$$

NOTE: Carnot showed how the whole of elementary plane trigonometry could be deduced from the addition and subtraction formulas. (Ball, *A Short History of Mathematics*, p. 88.)

FIRST-YEAR MATHEMATICS FOR HIGH SCHOOLS.

By C. B. WALSH,
Ethical Culture School, New York City.

Progress has wrought many fundamental changes in secondary schools. It would be futile here even to sketch this interesting phase of the history of education, but I ask your indulgence for an apparent prefatory digression from the topic assigned to emphasize the character of the development of our high schools. The trend has been unmistakably from the secluded precincts for the cultivation of selected scholars to the "poor man's college." It is not our province to analyze nor trace this change, nor note its relation to political and social readjustments—we are merely to recognize that in the evolution of this institution we have reached the stage where we are face to face with what Dr. Monroe calls the "universalization of secondary education." We no longer have the favored few whom we must fit for college but we have to deal with "Democracy's High School," as Lewis describes it in his book of that title.

From an administrative standpoint the junior high school is a concrete recognition of this change in the constituency and concomitant change in aim and purpose of secondary education. The keynote of this new organization is opportunity. It is to afford to an ever-increasing percentage of the school population a chance to find their interests and abilities by presenting a curriculum of great variety. The pupils, in short, by taking extensive courses in many fields, have numerous vistas opened before them. Then the senior high school through its carefully guided and guarded elective schedule gives the students the further privilege of more intensive work in the direction of their capacity.

The spirit of this junior-senior high school adjustment is evident even where the change in name and form has not been effected. The eighth and ninth school year programs, particularly the revision of graduation requirements, the so-called vocational adjustments, and many other such evidences, are convincing on this point.

It is natural that the administrators of our schools have been quicker to sense this situation than the subject specialists have been. In our actual classrooms we have gone on teaching much the same thing in much the same way as of yore. As teachers we have been Platonic in our conception of and adherence to the logical ideal, and in this pragmatic age we find

ourselves, therefore, somewhat "out of joint with the times."

Will you forgive me if I revive the famous old "camel story" at this point? Even at this time of delicate international relations its exaggerations offer their own apology. A Frenchman, a German, and an American were contestants for a prize disquisition on the camel. In preparation, one lovely afternoon the Frenchman visited the zoo. After a charming few minutes before the camel's enclosure he went home enthused. He had caught the *esprit* of the animal and reflected it in a fascinating little article. The German, on the other hand, went up to his study, locked himself in, lighted his pipe, and sat down to think. From the place of the camel in the category of animals, and other such scientific facts, he figured out the characteristics of that quadruped. He produced a ponderous treatise. When he was subsequently told that certain things he attributed to camels were not to be found in the actual animals, which he had never seen, he replied: "Well, if the camels haven't those peculiarities, they ought to have." The American bought a farm, collected camels from all parts of the world, watched them closely for months and then penned his scientific account of "Camels as They Are."

Far be it from me to liken the attitude of our educators to that of the Frenchman, and much less to compare our attitude as teachers to that of the German in the tale, but I may, with timely propriety, urge us all to be Americans.

The situation which I have been describing has given rise to the criticism that has been brought against the various subjects and our own has been made quite ruthlessly one of the targets. In short, we have not met the needs of our pupils by internal readjustments of our courses anything like as well as the general organization of the school has done. We are still compelling all to take the intensive view of a very limited portion of our subjects, thus thwarting the aim of our present secondary education, *viz.*: To present to all an extensive survey of life's possibilities as preliminary to the more intensive work in a chosen direction.

The offense of our mathematics courses in this regard has been flagrant and, it seems to me, especially so in the ninth school year, the first year of our present high school. (I am interpreting my topic as referring to that year.) Here we have traditionally given an intensive study of a limited portion of algebra the college entrance requirements. We have presented the future

artist with feats in factoring quite useless except to the college candidate and the pure mathematician. We have made the coming carpenter clear up a collocation of radicals and exponents which was truly a triumph of professional manipulation. No wonder he left school with a distorted notion of mathematics! No wonder the mortality of our courses challenged criticism! Here, then, in the first year of high school mathematics, we have the "horrible example" which illustrates the conflict between the internal and external adjustment to the new demands of high schools.

What is to be the outcome of this struggle? In the *Mathematics Teacher* for December, 1916, Dr. D. E. Smith answers this question in general thus: "The three years of required mathematics, covering the seventh, eighth and ninth school years, will include applied arithmetic, intuitional and constructive geometry, the uses of algebra, and an introduction to demonstrational geometry, and formal algebra. These years will open the doors of mathematics, will show its general nature, and will determine whether a student has the mental equipment for the further study of the subject. . . . All this is mere commonplace in the best European schools and the outlook is in favor of our adopting the best features there found."

The course which I have the privilege of outlining for you is a concrete answer to this query as to the outcome of the struggle in the ninth school year. It is the answer which the Ethical Culture School proffered several years ago and, with practical modifications and adjustments, is still giving. It has proved practicable but, of course, suggests only a stage in the evolution which such testimonial meetings as this should promote.

The specific purposes to which the department of mathematics addressed itself in formulating such a course were primarily these:

First: That it should lessen the mortality of the traditional first year course in mathematics by substituting for it a course more nearly adapted to the ability and interests of high school freshmen.

Second: That it should contribute to the solution of the question of how much mathematics shall be required of high school pupils who do not intend to enter college, or need further work in the subject for other vocational reasons, and with this objective, an effort has been made to plan a course adapted

to the needs and interests of pupils taking minimum requirements in mathematics.

It seemed evident to us that these needs and interests would include an appreciative knowledge of demonstrational geometry. In speaking of "needs" I know I am on the verge of a danger zone marked "disciplinary value." May I just say in passing that even the militant anti-disciplinary value advocates granting the transfer of ideals and habits when there are some identical elements. Under that restricted application, may I ask which fares better, demonstrational geometry or algebra?

Since I am to describe a course and not defend high school mathematics, for that is unnecessary, let me ask just one further question here in connection with the needs and interests of non-mathematical students. Is there any phase of our subject more fraught with practical applications than geometry? Pass on the answer to the utilitarians and you will have no trouble in finding them among either instructors or pupils.

Third: This course is intended to furnish the basis for vocational (or prevocational) and college preparatory work to follow.

To meet this threefold aim, the cry of many today is a fused or coordinate course. As evidence of this we find several texts "First Year Mathematics." In so far as they represent merely coordinate samplings of arithmetic, algebra, and geometry, and do not correlate them, it seems to me that they offer the fusion which spells confusion. In so far as they give information without developing power, they are unscientific and frustrate their aim. In so far as they give a consistent development of mathematics about some scientific core, borrowing as need be from the various branches, they present a felicitous correlation which reveals to the tyro the spirit of the subject and a panorama of its riches.

In a nutshell, our solution of the problem is, by a very gradual introduction to give a course in demonstrational geometry, with a limited syllabus, full of variety of applications, and introducing the algebra and trigonometry necessary. Let me clarify that dangerously succinct statement by considering certain details of the course.

First, the Introduction: The transition from the early work in mathematics to the scientific treatment of demonstrational geometry is made gradual both in time and method. The outline history of the evolution of the subject from an art to a science

arouses interest and prepares for an appreciation of the new point of view. A discussion of the uses of geometry brings design to the fore and construction work comes in naturally. Here is a chance to familiarize the student with the scientific instruments of geometry and accomplish what so-called observational geometry either has or is supposed to have done. Considerable time spent is not wasted on either the history or the construction work at the beginning. It is the time to "make haste slowly." The student is getting his background ready. He is developing eagerness to go on. He is fostering habits of neatness and observation.

When you are discussing the uses of geometry, surveying will, of course, come up and you have an opportunity of reviewing the mensuration work of the grades. This leads to a discussion of the fundamental concepts: surface, plane, line, point, and the like.

If not before this, certainly now, pupils will begin to ask questions which lead you into the real heart of the subject. They will ask, Why are certain constructions correct? Why are certain formulas accurate?

GRADUALLY, spelled with capitals, then, the class is ready to begin demonstrational geometry. Slowly, from the point of time, and as far as possible inductively, from the point of method, formulate those axioms, postulates, and definitions needed at once. Introduce nothing until needed. Then, at first largely in the form of experiment having the thought but not the mechanical arrangement and statements of a proof, develop the first few propositions. At first let the proof be wholly convincing, but divested of much of the form and detail demanded in more rigorous demonstrations. The essentials must be retained from the outset but details of form tend at first to discouragement and distraction. Let them grow!

Give the first two superposition proofs of congruence of triangles, for example, by having the pupils actually perform an experiment of cutting and placing, but giving sound reasons to justify all statements and observations.

Follow the two propositions immediately by numerous applications, such as measuring distances between points, one of which at least is inaccessible. Have the students actually make such measurements. For purposes of measuring angles, the pupils may make such simple, inexpensive substitutes for theodolites or such easily constructed astrolabes as are described in several modern texts.

We do not ask our pupils to write any proof until they have taken up say half a dozen theorems in the syllabus. Do not let the students write a proof until they are ready to do so reasonably well. There is no dearth of profitable tasks for them to be doing in this interim outside of class.

The introduction to demonstrational geometry I have just described is teeming with interesting and valuable exercise material. We have actually listed some one hundred fifty such problems.

Second, the Syllabus: By a syllabus of sixty-four propositions it is possible to give a comprehensive view of the whole subject. We selected our syllabus on three bases: (1) *Necessity.* Of course, a scientific sequence must be preserved and some theorems are retained for the convincing reason that they are needed; *e. g.*, "Lines drawn from each vertex of a regular polygon to the mid-points of the adjacent arcs subtended by the sides of the polygon form a regular polygon of double the number of sides." (2) *Interest.* Theorems which prove particularly interesting to young students have been retained on that ground, even if they could otherwise be discarded. Perhaps the Pythagorean proposition illustrates this point. (3) *Application* A theorem, whether necessary or interesting, is retained if it is prolific in applications. For example, the comparison of the areas of similar triangles.

The syllabus excludes all such propositions as those on inequality, and certain mensuration of sects relations, such as "the product of two sides of a triangle equals the square of the bisector of the included angle diminished by the product of the sects of the third side made by the bisector."

Our syllabus is grouped more naturally by topics than is possible under the somewhat artificial division into books. For example, the work in circles is not subdivided into Books II and V but grows as a unit out of the consideration of locus. This means, of course, that the retention of the sequence in the mind of the learner is greatly facilitated.

For pedagogical and psychological reasons, we have made radical changes in the traditional sequence of the syllabus. We pass as quickly as possible from the treatment of congruence to parallelism and its applications, greatly abridging the usual work of Book I. This we follow directly with the work in areas (usually treated in Book IV) because of its ease and numerous applications. Next, similarity is treated (Book III). Finally,

locus and the circle, traditionally Books II and V, are studied. This arrangement seems to present the work in the order of difficulty and brings the applications into the course very early.

Third, Correlated Matter: The aid of algebra is summoned when needed. Let me cite certain specific instances to illustrate:

Work with the single linear equation is needed in connection with the study of the sums of angles. Fractions are reviewed in introduction to the work in areas and are further reviewed and applied under the caption of Ratio, Proportion, and Variation, in introducing similarity.

As a useful tool in the application of the work in similarity, logarithms are used, and in this connection the theory of exponents in algebra is touched upon. Of course, only as much theoretical consideration in logarithms as is necessary for their intelligent employment is brought into the course.

In connection with similar triangles, the three trigonometric functions, sine, cosine, and tangent are explained and used.

The work in locus is introduced by a study of equations and their graphic representation. Here, then, is another correlation with algebra.

Four, Exercises: The nature of introduction, the bases of the selection and the sequence of theorems, and the type of correlated work in algebra and trigonometry have anticipated the statement that the great emphasis is laid in the selection of exercises upon applications.

Pupils find pleasurable profit in the making and using of simple instruments, such as parallel rulers, pantagraph, carpenter's level, baculus mensorus, squadra, and the like. In these instruments, often crude, the principles are more apparent than in the mechanically refined ones and pupils are often aroused to press on to the understanding and use of the more elaborate and accurate intruments of the transit type. Numerous general applications such as are found in the most recent textbooks are introduced.

If these details, indicating the gradual introduction, the selection of a restricted syllabus, the correlation of algebra and trigonometry, and the emphasis on the applictions have clarified the nature of the course, a pertinent question might concern its relation to the preceding and subsequent courses. To answer briefly, in the first place it is preceded by a correspondingly extensive practical course in algebra. It presupposes, however, as you have doubtless observed, little technical knowledge.

So far as final examination questions indicate the character of a course, for this introductory algebra work I refer you to an article in the *Mathematics Teacher*, March, 1916, Vol. VIII, No. 3, entitled "Specimen Examination in Elementary Algebra."

If we characterize, as we might well do, this ninth year course in plane geometry as a "first study," or, as the English put it, a "first reading," we may say it is followed by a "second study." This second course in plane geometry is elective and covers intensively the college entrance requirements. The syllabus of the first study is used by making necessary insertions. The original sequence is thus preserved but the total number of propositions is greatly augmented. The exercises used in this second study are primarily theoretic. This course we run parallel with a similar one in algebra, preparing the student by the end of the third high school year (eleventh school year) for college or Regents examinations in plane geometry and both parts of the algebra.

By way of testimony, permit me to say that our department has found this course most satisfactory *per se* and certainly in comparison with the traditional one. The young people have found their work interesting and have revealed a sort of spirit of research in embryo. They have shown us a variety of proof and applications that surprised us and revealed genuine thought on their part.

Present geometry inductively, and follow some such restrictions as I have tried to outline, and it will prove more interesting, and more thoroughly if not more easily understood than college preparatory algebra, and the comparatively greater value seems almost obvious. A comprehensive first view of geometry, omitting many theoretical ramifications, is simpler than an intensive study of abstract algebra. Though simple, such a geometry course would be a travesty if not scientific.

Gain simplicity through being scientific, not at the expense of such procedure. Nothing is so disconcerting to the beginner as a quasi-scientific performance.

In conclusion, then, the answer which the first year mathematics of the high school should give, in our estimation, to the present problem in the secondary school of adjustment to the new order of things, is to present a course in demonstrational geometry with a limited syllabus, borrowing freely from algebra and trigonometry, rich in aplications—a course which we might describe by calling it "A First Study of Plane Geometry."

PRACTICAL PUPIL WORK WITH YEASTS AND BACTERIA.[1]

By Henry R. Hubbard,

High School, Plainfield, N. J.

I have an impression, whether right or wrong, that a good many biology teachers refrain from attempting much practical pupil work with yeasts and bacteria because they feel that such work requires much time in preparation and an extensive and expensive laboratory equipment. The preparation of good exercises with these organisms does require more time than that of many other laboratory studies, I will admit, but the idea that an elaborate equipment is necessary is not correct. Some of the best exercises can be performed with the simplest materials.

At the risk of stirring up the old question as to which shall precede, structure or function, I shall suggest beginning the work on yeast with the microscopic study. The best medium I have found for growing yeast for microscopic work is Pasteur's Solution, and the most favorable temperature about 28° C. In this fluid and at this temperature the yeast plants develop rapidly, and within a day or two one can be sure of an abundance of chains and buds. Pasteur's Solution can be easily prepared according to the following formula:

H_2O, 850 g.; $(NH_4)_2C_4H_4O_6$, 10 g.; K_3PO_4, 2 g.; $Ca_3(PO_4)_2$, .2 g.; $MgSO_4$, .2 g. For fermentation as well as growth, add $C_6H_{12}O_6$, 150 g.

This will give enough material to supply two or three classes for two years. The solution should be kept in a glass stoppered bottle and sterilized each time the bottle is opened; otherwise it will be quickly spoiled by the yeasts and molds which will develop in it.

An exercise on fermentation may follow the microscopic study. The yeast and sugar solution may be placed in Erlenmeyer flasks fitted with delivery tubes, and the CO_2 collected in test tubes or cylinders loosely plugged with cotton. The pupils can note the difference in sweetness in the solution before and after the action of the yeast, and make their own CO_2 tests. I have not found it practical to have the pupils make individual tests for alcohol; instead they pour the contents of their flasks into one large round-bottomed flask, and we distill off enough of the alcohol to detect its odor. Perhaps some of you can suggest some better way of demonstrating the disappearance of the sugar. I have not found the Fehling's test satisfactory, as so much of the sugar remains unaltered at the end of the experiment. The practical application of this experiment needs no comment.

[1]Read before the Twenty-fourth Meeting of the New Jersey Science Teachers' Association, at the Normal School, Montclair, May 26, 1917.

A third experiment with yeast, and one of which I am particularly fond, has four distinct objects: To determine whether growth can take place without fermentation; to determine whether fermentation can take place without growth; to determine the elements or compounds necessary for growth; to determine the elements or compounds necessary for fermentation. This experiment requires no apparatus except fermentation tubes, yeast water, the various culture media employed, and a warm place in which to keep the tubes. The following table shows the method of recording results:

Table A.
Data.

	Contents of tubes.	Elements or compounds.	Volume of gas.	Turbidity.	Fermentation.	Growth.
1	Water	H_2O	0 c. c.	None	No	No
2	Water	H_2O	0 c. c.	None	No	No
3	Sugar	$C_6H_{12}O_6$	3 c. c.	Trace	Yes	No
4	Sugar	$C_6H_{12}O_6$	5 c. c.	Trace	Yes	No
5	Beef juice	C, H, O, N, S, Ca, Mg, K	0 c. c.	Much	No	Yes
6	Beef juice	C, H, O, N, S, Ca, Mg, K	0 c. c.	Much	No	Yes
7	Beef juice and sugar	C, H, O, N, S, Ca, Mg, K $+C_6H_{12}O_6$	6.4 c. c.	Much	Yes	Yes
8	Beef juice and sugar	C, H, O, N, S, Ca, Mg, K $+C_6H_{12}O_6$	6.7 c. c.	Much	Yes	Yes
9	Pasteur's solution	S, Ca, Mg, K H, O, N, C, P, Ca, Mg, K	0 c. c.	Much	No	Yes
10	Pasteur's solution	H, O, N, C, P Ca, Mg, K	0 c. c.	Much	No	Yes
11	Sugar and Pasteur	H, O, N, C, P Ca, Mg, K $+C_6H_{12}O_6$	9.5 c. c.	Much	Yes	Yes
12	Sugar and Pasteur's solution	H, O, N, C, P, Ca, Mg, K, $+C_6H_{12}O_6$	9.2 c. c.	Much	Yes	Yes

I have found that the success of this experiment depends almost entirely upon the method of filling the fermentation

tubes. Two drops of yeast water should be placed with a pipette or ink-dropper in the bend of the tube, then the long arm filled with the culture medium. This fluid should just seal the bend, but not extend up into the bowl.

Almost invariably the pupils approach this experiment with the preconceived idea that fermentation and growth are inseparable. It gives them a little lesson in drawing their conclusions from facts rather than from opinions.

There are many experiments which can be performed with bacteria. I will mention only five: First, the microscopic study. The microscopic study of living bacteria is useful in giving the pupils a conception of the intense activity of these organisms. One glance into a drop of beef broth or hay infusion full of wiggling bacilli and twisting spirilla is worth a dozen sermons on hygiene. High powered microscopes are not necessary for this work; a magnification of 500 diameters will show many forms. A saucer of beef broth or hay infusion left exposed to the outdoor air for several hours then kept in a flask in a warm place for two days will furnish an abundance of material. To study carefully the forms of different bacteria stained slides and charts or illustrations are necessary. The teacher can prepare slides without great difficulty or, if she prefers, she can doubtless borrow them from the local board of health. The M. J. Breitenbach Co., of N. Y., manufacturers of Peptomangan, publish an excellent little chart which they will send to a teacher free of charge.

The second experiment has for its object the study of the effects of single and discontinuous sterilization on bacteria. The pupils fill with beef broth and peptone, furnished by the instructor, 12 test tubes for each laboratory table. These they divide into three lots. The first lot they sterilize 135 minutes; the second and third 45 minutes each. The next day they sterilize lots two and three 45 minutes; the third day, lot three 45 minutes. Between and after sterilization the tubes are kept warm. Two or three days after the last sterilization all the tubes are ready for examination. Results may be recorded as in table B on page 798.

The application of this exercise to vegetable canning this summer is evident. Without doubt the food could be sterilized by a single sterilization continued for several hours, but the shorter sterilizings on three consecutive days would certainly consume much less gas.

For the third experiment the pupils are furnished with sterile agar tubes. These they inoculate from the mucous membrane of the mouth, from under the finger-nail, from the skin of an apple purchased at an out-of-door fruit stand, from a dollar bill, etc. After the tubes have incubated two days, they examine them and observe the colonies of bacteria that have developed. There are always a few pupils who are sufficiently interested in the work to make microscopic examinations of the colonies.

Table B.
Data.

Table No.	Sterilized once 135 min.		Sterilized twice 45 min. each time		Sterilized 3 times 45 min. each time	
	Bacteria		Bacteria		Bacteria	
	Present	Absent	Present	Absent	Present	Absent
1.	1	3	1	3	0	4
2.	1	3	1	3	0	4
3.	1	3	0	4	0	4
4.	1	3	1	3	0	4
5.	2	2	0	4	0	4
6.	1	3	0	4	0	4
Totals	7	17	3	21	0	24

I have observed that this experiment appeals quite strongly to the sporting instincts of the boys, for frequently I notice them making wagers—after class, of course—as to which one will have the smallest number of colonies develop from his mouth. A pupil who obtains a flourishing colony of catarrh germs from under the finger-nail, as one of mine did this year, will probably be more careful to keep the fingers out of the mouth and nose henceforth.

In the ventilating system of the Plainfield High School, the heated air is forced through a chamber in which a spray of water is falling. This is supposed to wash the bacteria and dust out of the air before it reaches the classrooms. Each year we test the efficiency of this apparatus by exposing twelve sterile agar plates in petrie dishes for fifteen minutes in twelve different rooms, and at the same time twelve more plates at different points around the outside of the building. After the plates have incubated two days, the pupils examine them and compare the number of colonies on the plates exposed indoors with those on the plates exposed outside. They record

the results in tabular form, calculating the average number of colonies indoors and outdoors. The following chart indicates the result of our experiment this winter, and this is by no means an unusual result:

Table C.
Data.

	Location in building Room No.	Number of colonies		Location outside of building	Number of colonies
1	120	8	1	East	35
2	331	3	2	West	10
3	Library	0	3	Front	100
4	160	0	4	Back	25
5	318	1	5	West	25
6	270	3	6	East	9
7	261	0	7	West	18
8	340	5	8	Back	3
9	351	1	9	Front	12
10	338	3	10	East	200
11	221	0	11	East	50
12	101	8	12	West	9
Total No.		32	Total No.		496
Average		3	Average		41

It certainly demonstrates to the pupils and their parents the efficiency of our ventilation system in removing bacteria from the air. Perhaps it is only fair to the Plainfield atmosphere to state, however, that I always perform this experiment if possible on a windy day when plenty of germs are being blown around outside. The results are much more startling.

The object of the last experiment is to determine the effects of pasteurizing and sterilizing on milk. The pupils fill 216 tubes with raw milk. These they divide into three lots; the first lot they leave raw, the second they pasteurize, the third they sterilize. Each lot they then divide into two sets, one of which they place in a refrigerator, the other in the incubator or some other warm place. The next day they examine one-third, the following day another third, and the next day the remainder. This table shows the form of recording observations.

It shows them, among other things, that pasteurized milk will not keep indefinitely, as many people think. It indicates also the action of lactic bacteria in checking the growth of putrifying bacteria in the human intestine. It does not indicate anything, however, as to the effects of pasteurizing and sterilizing on the digestibility of milk.

Table D.
Data.
Condition of Milk.

Time	Raw		Pasteurized		Sterilized	
	Cold	Warm				
1 day.....	12 normal	12 sour	12 normal	11 normal 1 sour	12 normal	12 normal
2 days....	12 normal	12 sour	12 normal	6 putrid 5 normal 1 sour	12 normal	12 normal
3 days....	7 sour 5 normal	12 sour	12 normal	12 putrid	12 normal	12 normal

I have said that the apparatus required for these experiments is neither elaborate nor expensive. A microscope with an oil-immersion lens is a help but not a necessity. A good incubator can be procured from Eimer & Amend for about $25, but this is also not a necessity. Before I had one, I used to place my cultures on top of the boilers in the engine room. If you cannot afford an Arnold sterilizer, you can substitute a large double boiler. For pasteurizing, a tin kettle with a hole punched through the cover for the insertion of a thermometer will do very well.

The glassware and other apparatus required consists of twelve small fermentation tubes, one or two gross of heavy test tubes without lip, 5 x ⅝ inches (these can be obtained from the Williamstown Glass Co., Williamstown, N. J., for $2.20 per gross), a few wire baskets to hold the test tubes, pipettes or ink-droppers, inoculation needles, twenty-four petrie dishes, one or more wax pencils for labeling the tubes and petrie dishes, and a supply of absorbent cotton for plugs. Glass tubing, flasks, etc., can be borrowed from the chemical laboratory if necessary. Stains can be prepared easily by the teacher or purchased at small cost. The local board of health will probably be glad to supply agar shreds and peptone or prepared agar in small quantities at a nominal price, and to give suggestions as to the preparation of materials.

A supply of glass cleaning mixture is necessary for cleaning fermentation tubes, and saves much time and energy in cleaning test tubes and petrie dishes. To prepare it, dissolve 80 g. $K_2Cr_2O_7$ in 300 c. c. hot H_2O and add to this drop by drop from a burette 460 c. c. H_2SO_4. This solution will remove organic matter from glasssware in from fifteen minutes to an hour. It can be used repeatedly till the red crystals disappear and the mixture begins to turn green.

The experiments I have outlined are valuable, it seems to me, because they give the pupils a little insight into bacteriological methods, and substitute a definite conception of the forms and activities of yeasts and bacteria for the more or less hazy idea that most people have of "germs." They have practical applications to the pupils' daily lives and personal hygiene. They are more stimulating than many of the available experiments in plant physiology, in that their results cannot be foretold by the pupil. If a student has even a mediocre imagination, or has used his eyes to any advantage, he can make a pretty shrewd guess as to what will happen when the cotyledons are removed from a seedling, when a stem is placed in a bottle of red ink, or when a plant is grown in a box illuminated from one side only. He cannot tell what will happen when yeasts and bacteria are grown under different conditions, hence a greater interest in the experiment.

But the greatest value of a number of these exercises lies, I think, in the fact that their observations can be recorded, as in many physics experiments, in tabular form, giving the pupils training not only in accurate observations but in thinking out logical conclusions from their data. Such experiments have a distinct advantage, I believe, over many of the dissections and living studies carried on either in the laboratory or the field, which train the pupils in observation and in ability to describe what they see but not in reasoning power.

ANNOUNCEMENT.

Messrs. Doubleday, Page & Company have concluded that the present time offers a great opportunity for starting the Educational Department which they have long been preparing to organize.

The last three years of war have made radical changes in the life of all nations; schools will have to teach about the world, not so much as it was, but as it is and will be. Textbooks will have to be written which recognize the great changes that have come to all peoples in economics, history, geography and science. Doubleday, Page & Company have no old books to discard, and are ready to make great efforts to meet new conditions and new needs with textbooks that fit these requirements.

THE VALUE OF A SCIENCE CLUB IN SECONDARY SCHOOLS.

By Neil E. Gordon,
The Park School, Baltimore, Md.

There is no *real* teacher of secondary science who feels that one of his important problems is that of arousing and holding the interest of his students. Perhaps there are two main reasons for this. First, because the subject is generally elective, and second, because there seems to be something about the very nature of every science subject that appeals to the average high school pupil. They seem to long to know more of the wonderful beauty and phenomena that surround them; and equally anxious are they to tell us what they have read or heard about these wonderful things. They are even more anxious to tell if that which they have read or heard is not in the textbook. Their ideas are many times fine, yet so irrelevant to the subject at hand, or rather to the college requirements, that one must say, "John, let's talk that over after school." This request, be it ever so gentle, gives the student a jolt. He wishes the whole class to hear it as well as you, and furthermore the whole class might well profit from his discussion. It was to meet this demand for informal discussion that our science club was organized. In fact, it had no formal organization the first few weeks. The students simply came together to discuss scientific things. Their interest became greater and they proposed to organize. We at first hesitated to lend them our support because we felt their interest would soon wane and the enthusiasm would be shared only by the teachers. Since they were willing to take the initiative, we told them to go ahead. They at once deemed it necessary to have a constitution and elect officers. Their constitution is very brief and to the point. The officers are a president, vice-president, secretary, and treasurer.

Because of its unusual origin it naturally had for its charter members those who were particularly interested in science, but before the end of the year the members considered it best to restrict the membership to one of scholarship. These proceedings were fixed by vote at the last meeting. They had a provision in their constitution which limited membership to those who had taken or were taking some science course. It makes no difference what science. Lack of uniformity in membership has in no way hampered the program committee.

Regular program meetings, usually two hours in length, were held every three weeks at the school or at the home of some member. The officers constitute the program committee. This committee confers with the science teachers in regard to the subject matter for each program and also urges individual members to propose topics of special interest that they wish to discuss or hear discussed. The meetings have been almost entirely taken care of by the pupils. Many papers have provoked animated discussion which continued long past the time for adjournment.

In order that you may judge whether this club has warranted its existence, I will mention a few experiments which the members have carried out and a few papers which they have prepared in the short year of its existence.

At the third meeting of the club we were invited to the home of one of the members, as he was to be one of the largest contributors to the program that evening. His topic was, "Moving Pictures, How Made and Worked." He brought to light all the freaks in the work and handled the whole topic in such a capable way that he held the interest of every last member of the club to the finish. While visiting his laboratory we found other experiments which he had carried out along the same line.

After taking up neutralization in the chemistry class, the problem of investigating the different kinds of ammonia was proposed to a member of the science club. He obtained samples of all the different kinds he could find on the market. The number of different kinds is surprising. He determined the amount of ammonia in 10 c.c. of each sample. Knowing the price of each sample, he brought before the meeting, in tabulated form, the value per cu. cm. of each sample.

A similar plan was carried out in regard to baking powder. It was suggested to a member while carbon dioxide was being taken up in the chemistry class. The original aim was to determine the available amount of carbon dioxide in the different kinds of baking powder, but the boy grew so interested that he would not stop short of a complete analysis of each kind. It is needless to say that this was no small task for an inexperienced analyst. He seemed to prefer hunting out all his own methods so that he might call the work his own. When he brought his work before the meeting in tabulated form, together with his experience in investigation, he made it intensely interesting for all present.

When electric furnaces were being discussed in class, the task of building one was suggested to one of the members of the club. After two or three failures in the burning of the clay he brought it to a successful issue. Not only did he have a chance to demonstrate it to the members of the club, but nearly every member of the school wished to see it work. Because of its available high temperature, it became a very useful piece of apparatus during the study of the metals and alloys. There was scarcely any single metal or combination of metals of which the melting point was not tried.

This by no means exhausts the experimental investigations that were carried out, but the work of the club was not all experimental. Many papers were prepared to keep the members up to the latest developments in the wide range of science. Each member prepared a paper on investigations that had been carried on in those fields which were of particular individual interest to him. The programs were varied, as a short and brief account of a complete meeting will show. The first feature of the program consisted of a talk on the subject of anaesthetics, their history and the cause for their producing unconsciousness. Then there followed an interesting discourse on the subject of polar explorations, a summary being given of its entire history. The third talk dealt with certain phases of coal mining, and the fourth was in the nature of an explanation of some objects of scientific interest collected by one of the members of the club. The meeting was concluded by the showing of slides illustrating certain of nature's phenomena.

At present it is felt that this science club enables one to cover a vast amount of ground that otherwise must be neglected. Due to the privilege of having the benefit of each fellow-member's individual work, everyone has an opportunity to gain an intensely interesting and widely comprehensive fund of information. There is every indication that this organization will assume even greater proportions in the future than it has in the past. Its good influence in the past and its bright prospects for the future are due to the initiative of the charter members of 1916.

AIMS AND METHODS OF PROJECT WORK IN SECONDARY AGRICULTURE.

By C. H. Lane,
Chief Specialist in Agricultural Education, U. S. Department of Agriculture.

In thinking over this subject I have been led to consider what is being done along this line in those states which have provided definite state aid for agricultural instruction in high schools, and instead of giving my own point of view as to the aims of project work in secondary agriculture, I shall quote statements of men in charge of and interested in home project work in secondary agriculture in those states which have made the most progress in this phase of secondary agricultural instruction.

In 1914, Prof. W. H. French, of the Michigan Agricultural College, stated in his Report of Agriculture in the High Schools of Michigan that, "in order that practice may be combined with theory the class room work and laboratory work done during the year is supplemented during the summer season by home projects.

"The home project work has its intensely practical educational value, and at the same time it is distinctly vocational. Frequently it will assist the boy to determine the question whether he desires to become a farmer. The actual commercial value of the products to be raised, of course, cannot be stated at this time, and as this is the first year since home projects have been particularly recommended we are unable to give any figures as to the value of the products. The working out of the home project always develops a deeper interest in agriculture and a keener insight and appreciation of the processes and the purposes of farm operations."

Again, in his Report of Agriculture in the High Schools of Michigan in 1916, Professor French further states that, " 'home projects' may be defined as a piece of farm work selected by the student with which to illustrate some theory, or to demonstrate some plan of procedure which has been presented in the course of the school instruction. For instance, a certain theory has been presented in regard to corn culture, and the boy undertakes to raise an acre or more of corn in accordance with the instruction. This would constitute a home project, or if a certain plan of raising alfalfa had been taught, the boy would elect to demonstrate the truth of the teaching by raising a plot of alfalfa; or the necessity for keeping a record of milk or butter

production of dairy cows has been taught in school, and the boy undertakes to keep a record of each cow in his father's herd for the season to show whether they are profitable animals to keep on the farm. We suggest two types of project work—the short time project, which can be completed in a few weeks or months, and the long time project, which may require a year or more for complete demonstration.

"During the summer of 1916, 600 high school students are conducting agricultural projects at the home farm. These projects include a great variety of work, such as the raising of corn, potatoes, keeping records of a dairy herd, pruning, spraying and renovating orchards, raising poultry and raising swine. This work adds to the agricultural instruction the commercial idea. It affords an opportunity to put theories into practice, and also is a strong factor in the vocational decision of the young men. Summer projects of this type can be conducted successfully only where the agricultural instructor is employed by the year and thus given an opportunity to supervise and direct the work of his students during the growing season. This supervision necessarily brings the instructor in contact with the farmers and thus affords an opportunity for mutual help and suggestion."

Probably no place in the country has developed the home project plan on a wider scale than has Massachusetts. The legislature has provided state aid for carrying the home project plan into effect. According to the Report of the Massachusetts State Board of Education on Agricultural Education, the plan has an educational process which possesses unquestionable merit, because farming activities readily resolve themselves into what may be termed farming projects. The farming project, according to them, is something to be done. It may include (1) improvement projects; (2) experimental projects, and (3) productive projects. A farming project is, further, something to be done on a farm which will involve a limited and definite amount of equipment, materials, and time, and which would be directed toward the accomplishment of a specific and valuable result, and finally, a farming project, as the term is used, is a thing to be done on a farm which in the preparation for doing it and in the carrying of it out to a successful result, would involve a thoroughgoing educational process. Therefore, a complete definition of a "project," as outlined by the board, has three elements: "(1) Something to be done on a farm; (2)

under specific conditions and for a specific and valuable result, and (3) requiring a thoroughgoing training."

It is needless for me to enter into a discussion of the home project plan as worked out in Massachusetts when this plan has already been written up in bulletin form by Mr. R. W. Stimson, Supervisor of this work in the state, and published by the Bureau of Education, Department of the Interior.

ESSENTIALS OF A SUCCESSFUL PROJECT.

Definition.—The following definition of a home project is suggested: The term "home project" applied to instruction in elementary and secondary agriculture includes each of the following requisites: (1) There must be a plan for work at home covering a season or a more or less extended period of time; (2) it must be a part of the instruction in agriculture of the school; (3) there must be a problem more or less new to the pupil; (4) the parents and pupil should agree with the teacher upon the plan; (5) some competent person must supervise the home work; (6) detailed records of time, method, cost, and income must be honestly kept; and (7) a written report based on the record must be submitted to the teacher. This report may be in the form of a composition or a booklet.

Lack of unity in definition.[1]—In many sections where teachers talk of projects there seems to be a lack of understanding of the plan and a lack of unity in definition of the term. According to some teachers any effort toward giving their work a practical turn is termed a project. Others have used the word in lieu of "practicum," so that simple laboratory exercises are spoken of as projects. In a general way a project is anything mapped out or planned to be done. The term has been used for years by this department in connection with its work and that of the experiment stations. The term "home project," however, has come to have a special meaning in connection with the teaching of agriculture. It is essential that this meaning be agreed upon before plans for carrying out the idea are discussed.

A project to cover an extended period at home.—A distinction should be drawn between a project and a simple exercise used as a practicum to illustrate some principle, or for the purpose of increasing skill in some operation of farm or shop. A project, to be worthy of the name, should involve skill in many operations and the application of a number of principles. To accomplish this it should cover a branch of farming that will extend over a comparatively long period of time. The testing of seed corn may be cited as an example of a simple laboratory exercise performed at school. The stringing of seed corn would be a suitable home practicum, the aim of which would be to acquire skill in a useful operation. The growing of an acre of corn would involve both of these operations and many others, hence it would be a worthy project.

It is obvious that if the term "home project" is applied in a strict sense the work should be carried on at home. In case a suitable project may not be arranged for a student at home, there should be no objection to the student working away from home. If this work can be properly correlated with his course of study and meet other requirements of a project there should be no objections to accepting it as a substitute for a home project.

[1] U. S. Department of Agriculture *Bulletin* 246.

The project to be a part of the instruction in agriculture.—The project should have a definite relation to the course of study. If the student is taking a course in farm crops his project should be along the line of crop production; if he is studying animal husbandry, his project should be connected with the care of animals; projects in fruit growing or vegetable gardening may accompany courses in horticulture; and if a special course in farm management is given, special problems of management should be assigned as projects.

Boys and girls not taking the course in agriculture may be induced to take up some special phase of practical agriculture at home, but such work does not come within the definition of a project. A student while taking a course in animal husbandry may start to keep records of the home herd in connection with a dairy project, his interest may cause him to continue the work the following year while he is taking a course in fruit growing, but some work pertaining to the production of fruit should then constitute his main project.

The project to present a new problem.—It should be borne in mind that the primary aim of the home project is educational. A project should be considered in the light of what the student may learn from it in principle and practice. A student may grow an acre of corn year after year and continue to learn something new, but if the work of the first year has been properly planned and supervised it will have far greater educational value than in the succeeding years. After growing corn one year the student may better take up some other crop or, better still, an entirely different phase of farming.

Pupil, parents, and teacher unite upon plan.—The home project when properly administered is an excellent means of bringing the home and school together in their educational problems. The teacher should know the home conditions surrounding the student and should not attempt to plan a project without first getting the consent of the parents. Not only should their consent be obtained, but every attempt should be made to secure their hearty cooperation. Whether a written agreement is made or not will depend upon the relation of the project to the plan upon which the agricultural course is conducted. In productive projects and in other projects as far as possible, the student should be given entire responsibility regarding the work and should have a financial interest in its outcome. If the student is using his father's land or live stock, he should pay rent or interest on a fair valuation. He should work with an understanding that he will participate in the profits, if they are not all to be his, and at the same time feel that he will be responsible for any losses.

Competent supervision essential.—Supervision is necessary in order that those in charge may be sure the work is carried out as outlined. It is even more essential that some one take an active interest in aiding with problems which may arise, and in giving encouragement. Where it can be arranged it will prove most satisfactory as a rule to have the teacher who is conducting the class work supervise the projects connected with the courses given. The summer season is the most important time for most projects, hence in States where the teaching of agriculture is based upon the home project, teachers are employed for the entire year. If any vacation is allowed them it is taken in the winter. Effective supervision means frequent visits to the homes of the students. In districts where the students are scattered over a wide area, some special means of transportation will be essential to efficient service.

Detailed records to be kept.—A valuable part of the training secured in connection with carrying out a project will be obtained in the keeping of

accurate records and accounts. It will be helpful, if not absolutely necessary, to give a few lessons in elementary cost accounting before the work is begun. The record should cover points learned in connection with study relating to the project as well as experience gained in practice. In keeping accounts such items as rent of land and interest on investment should not be overlooked. Accurate account should be kept of the time expended and charges and credits made upon a fair basis. Accuracy and fairness are especially important in the keeping of accounts where there is any contest feature in conducting the projects.

The following record blank for a potato project may be adapted to other crops. It is suggestive of forms which may be used for other kinds of projects.

RECORD BLANK FOR POTATO PROJECT.

Soil Preparation.

Character of soil..... Crop for 5 years past.....
Date of plowing..... Dates of harrowing.....
Implement used..... Implements used.....
Depth plowed..... Cost of harrowing.....
Cost of plowing..... Condition of land when planted.....

Crop Planting and Cultivation.

Variety of potatoes planted..... Kind of fertilizer.....
Kind of seed..... Amount of fertilizer per acre.....
Cost of seed and planting..... Cost of fertilizer.....
Depth of planting..... Dates of cultivation.....
Distance of planting..... Implements used.....
Percentage of stand..... Cost of cultivation.....

Harvest and Yield.

Date of digging..... Yield in marketable potatoes.....
Method of digging..... How disposed of.....
Days from planting to digging..... Cost of harvest and marketing.....
Total yield.....
Remarks.....
.....
.....

Approved:

.....Teacher
.....Student Age.....
Post office..... School.....
County.....

Estimate the rental of your land and your time at a fair valuation. Count all commercial fertilizers at actual cost and barnyard manure at what it would bring in the district.

Expenses.

Rent of land..... $.....
Preparation of seed bed:
  Horse labor.....
  Student's labor.....
Cost of seed.....
Cost of planting:
  Horse labor.....
  Student's labor.....
Cost of fertilizer.....
Cost of cultivation:
  Horse labor.....
  Student's labor.....

Cost of digging:
Horse labor.....
Student's labor.....
Cost of sacking, storing, and marketing.....

Total cost.....$.....

RECEIPTS.

Total value of marketable potatoes,.....bushels, at.....$.....
Value of cull potatoes,.....bushels, at.....
Value of potatoes kept for seed,.....bushels, at.....

Total receipts.....

Net profit.....

A written report to the teacher.—The records kept are to be made the basis of a written report to the teacher upon the completion of the project. This report may be in the form of a composition, or it may be somewhat of the nature of a thesis. There is an excellent opportunity in this work to correlate the work in agriculture with the work in English. Teachers and supervising officers will find among these reports some which may be used to advantage in arousing interest in the work. Photographic records will be found very useful for the same purpose.

COMMERCIAL AND INDUSTRIAL DEMANDS ON THE CHEMISTRY OF TOMORROW.

BY B. J. RIVETT,

Detroit Northwestern High School.

As American citizens and as teachers we should be alive to every question that affects the future industrial development of the United States. In my opinion the commercial and industrial demands on the chemistry of tomorrow is one of the vital subjects before us today. The American Chemical Society in the meetings this year have made it one of the chief topics of discussion. This Association representing the great Middle West may well consider its significance.

The problem will be discussed in four general aspects:

1. The present condition of commerce and industry in this country.
2. The importance of chemistry in modern civilization.
3. Commercial and industrial demands on chemistry.
4. The work of the schools in meeting this demand.

The United States is the most prosperous and the wealthiest nation in the world today. Our present prosperity is due in part to abnormal conditions. European nations are demanding our foods, our metals, and our manufactured articles and they

are willing to pay war prices for them. In my home city, mechanics are getting from five to eight dollars a day. There is work for everybody and even the sewer digger receives as high as five dollars a day. No one believes these conditions will continue; every one thinks there must be an adjustment of prices and wages when the European War closes. It is the future that we must consider. What is to be the position of the United States as an industrial nation in the next twenty-five years? It is an important question for every manufacturing center and to the nation as a whole.

All are agreed that the next quarter of a century will see a period of intense commercial rivalry among all the nations of the earth. The United States will have to reckon with Germany. England, France, and Japan in the world's trade. The American workman is paid the highest wages of any workman on earth and no one advocates a lowering in his standard of living. How then shall we meet this competition? Shall it be a high protective tariff? This will help some of our infant industries like the dye industry, for example, but it is not a panacea for all our ills. It is evident that as a manufacturing nation we must produce an article equal in quality and price to the one manufactured abroad. How is this to be accomplished? By more economical methods of production and by elimination of waste. This requires better-trained workmen and more and better-trained technical experts. Charles Steinmetz, the distinguished engineer, in discussing the future industrial development of the United States, points out the fact that our great wealth has been due to our abundance of natural resources and cheap immigrant labor. He states further that we have depleted our soil, wasted our timber and other resources, and that our position as an industrial nation depends in the future on our industrial efficiency.

What part will chemistry play in this problem? The importance of chemistry in modern civilization is well expressed in the essay to London chemists by Sir William Ramsay: He says, "The country which is in advance of the rest of the world in chemistry will also be foremost in wealth and in general prosperity. For the study of chemistry is so closely bound up with our development in all kinds of industry, with the arrestment of disease, and with our success in war, that it is essential to a wealthy, healthy, and peaceful nation. The electrician is dependent on the chemist for the iron suitable for his dynamos; the engineer for the materials which he uses in his construction;

and the scouring, bleaching, and dyeing of the fabrics with which we are clothed; and the manufacture of the paper on which we write, and the ink with which we soil the paper; the provision of our food supply; and the removal of effete matter from our houses; the preparation of our medicines; and the synthesis of high explosives with which warfare is now conducted; all these belong to the domain of the chemist, and without him we should lapse into the semi-barbarism of our ancestors."

If we are to believe Sir William Ramsay then, we need more chemists; we need further application of chemistry to our problems. More interest has been aroused in the study of chemistry in the past two years than ever before. The number of students in chemical engineering at the University of Michigan is now second in the engineering department. The public is just beginning to realize the importance of chemistry. There has been a demand for more vocational training in our schools and more practical courses in the school curriculum.

There are many hopeful indications that the schools and scientific societies are alive to the needs of the nation. It was the consensus of opinion at the spring meeting of the American Chemical Society that research work in pure science and applied chemistry should be encouraged in the universities. Another point that was emphasized was that the universities and the technical schools on the one hand and the industries on the other should be brought together. Some universities, notably Wisconsin and Illinois, have enlarged the idea of the function of a university. They believe that the university should not only interpret the knowledge of the past for its own sake, but that it should apply this knowledge directly to the solution of all the problems of the state, industrial, economic, civic, and educational. Agricultural colleges are aiding the farmer, high schools in rural communities are teaching the fundamentals of agriculture, and in many cities the technical high school is doing a great work in training pupils to become more intelligent and more skilled in the trades.

It may be of interest to state something of the work that is being accomplished in the chemistry department of the Detroit Cass Technical High School. The building is constantly in use from 8 a. m., to 10 p. m., six days in a week during the school year, and a session of eight weeks is held during the summer Elementary chemistry is begun in the second year of the high school and is required of all pupils of the mechanical depart-

ment. Qualitative analysis is studied the third year and quantitative analysis the fourth year of the high school. In addition to the regular day pupils, men from factories come in the afternoons. The Solvay Company and the other companies send their foremen to study chemistry. In the evening school there are seven instructors of chemistry. Two hospitals are sending their student nurses one evening a week. A four year pharmacy course is offered in both the day and evening school. The class in electroplating illustrates the possibilities of applied chemistry. This class is composed of foremen in the electroplating rooms of automobile and stove factories. Not one had ever studied chemistry previously, but last year they learned to analyze solutions and they solved many of their problems of electroplating in the evening school. This year they have a room supplied with tanks and direct current and they are conducting experimental work in electroplating. The importance of this work to the industries involved can not be overestimated. A new one million dollar addition to the Cass Technical High School is to be erected and it is planned to give still more applied chemistry.

The Detroit Central High School also offers an advanced chemistry course. The elementary course is offered in the third year of the high school and a year of advanced chemistry in the fourth year. About fifty students are taking this advanced course. Many of these are preparing for the study of medicine and engineering and this work is accepted at the Detroit College of Medicine and the University of Michigan.

In the light of our discussion, what should be taught in elementary chemistry in the academic high school. Some of our pupils go to technical schools and universities and their requirements must be considered. Domestic science is making certain demands. Many more pupils on leaving school go directly into all kinds of commercial and industrial establishments. What do they demand? They want young people who are trained to think. Chemistry should enlarge their knowledge of the world about them, it should give them a certain amount of hand training and it should teach them to think, to use their heads. In my opinion we should teach them applied chemistry, but we should not neglect the fundamentals, the law and principles of the subject.

The experiments of Mr. Willis Clark, instructor at Detroit Central High School, suggest an improvement in our laboratory

work. In response to the criticism that the bright pupil has no opportunity to exercise his ability in the ordinary class, Mr. Clark organized a class of twenty-eight of his best pupils. This class was set to work on preparation of chemically pure substances from the crude natural or manufactured materials. They made pure potassium chloride from the crude potash fertilizer, pure sodium nitrate from the crude natural product, and from these two compounds, potassium nitrate. Pure potassium salts were made from wood ashes. Sodium thiosulphate, ammonium sulphide and other compounds were prepared.

At the Detroit Northwestern High School we have begun some work in preparations. Formerly, the liquor left in the hydrogen experiment (zinc and sulphuric acid) was wasted and the pupil demonstrated only the presence of hydrogen. This year we saved this liquor and part of the class crystallized out the zinc sulphate. We plan to extend this work further in recovering the manganese salts from the chlorine experiment, the potassium chloride from the oxygen experiment, and the sodium hydrogen sulphate from the preparation of nitric acid and hydrogen chloride. This work in preparations gives the pupils training in technique and in the advanced chemistry. They showed a better grasp of the subject than those who did the regular laboratory work. I believe there are great possibilities in this preparation work in elementary chemistry.

In conclusion, it is the opinion of many that we are entering on a period of great commercial and industrial rivalry; that economical production is necessary; that chemistry will help solve many problems. We need more chemists, more applied chemistry in our technical high schools, more research work in applied chemistry in universities. In academic high schools, we can do something in training pupils in technique, and can awaken in them a desire to know more of the subject, we can aid in their general education by giving them a solid but practical course.

CLASSROOM SAYINGS.

Drawfiling is holding the file by both hands.

Dew point is when the temperature is cooled below exaggeration.

Teacher: "What is a transparent body?"
Bright Young Lady: "A transparent body is one that you can see through."
Teacher: "Give an example."
Bright Young Lady: "A ladder."

SOME REFLECTIONS ON THE CURRENT DISCUSSION OF SECONDARY MATHEMATICS.

By WALTER H. WOOD,

Westtown, Pa.

One very evident and fundamental difficulty inherent in all argumentative discussions is the securing of clear and adequate definition of all terms and symbols employed. This appears to be a serious phase of the current controversy regarding the relation of mathematics to education. The psychologist uses a set of terms, for the most part of his own making, intended to define or symbolize the facts and processes which constitute the subject matter of his science. When, however, he addresses himself to the problem of the place, value, and function of mathematics in the educational program, he too often applies the technical machinery of psychology to the content, procedure and aims of mathematics, both traditional and professed, without sufficiently analyzing or defining them and usually without recognizing their vital meaning. Thus the psychologist frequently misinterprets or distorts mathematical values and holds them up for the ridicule of the novelty-seeking crowd.

On the other hand, the mathematician, more or less appreciative of the need for pedagogical progress and moved by a profound faith in the educational importance of his subject is aroused to its defense. He attempts with the courage of deep-seated conviction and with some show of results to give a new meaning and a modern interpretation to the old ideas and words cherished and endeared by long and reverent association with the educational function of mathematics. Not having mastered the method or the vocabulary of the modern psychologist, he is unable to meet him with confidence and certain step upon his own ground. He makes passes in the air, but the psychologist is not there. Too often the mathematician, supposedly an expert in logical demonstration and deductive reasoning, bases his arguments not upon scientific data but upon an accumulation of personal opinions of mathematicians, philosophers and educators, past and present, to whom the modern psychology was unknown or is an unexplored field.

It is not improbable that we are only in the beginning of a lively period of experimentation and research in mathematical pedagogy. It should go without saying but apparently it needs to find expression that, in striving to arrive at conclusions which shall be universally valid and generally acceptable to the

educational world, the mathematician should translate his ideas, his data, his processes, his cherished traditions into precise and equivalent modern psychological language and symbolism. In so far as his ideas are true or valid, they will admit of some such reduction and in proportion as they are invalid or untrue, their falsity and inadequacy will find some sort of quantitative or qualitative expression.

In either case, this process of translation or reduction should prove of considerable importance in several ways. If the method and technique of the psychologist are correct and his hypotheses sound, a solid structure will result and the latter glory of mathematics will transcend any that it has ever known. If, however, the psychologist himself is following a will-o'-the-wisp, the well grounded experiments of the mathematician may serve in some degree to indicate the true highway of educational progress.

To illustrate, let us consider briefly the much mooted matter of "mental discipline." The modern psychologist states the case somewhat negatively but clearly. He asserts that the mind is an integrated unit and cannot be separated or resolved into component factors in any mental activity, the so-called "faculties" of the older psychologists being merely modes of mental functioning. Perception, imagination, reasoning, etc., are special ways in which the mind acts. But, "since experiences are not alike in kind, in intensity, in nature, adjustment to one phase of life will not help the mind to function in another *unless the two phases are similar.*" "This similarity may be one of content, of procedure, or of aim, and the 'transfer' will be only in proportion to the degree of similarity." The mathematician should therefore devote himself to a careful analysis of the various departments of knowledge and of the various functions of mental activity in order to discover and experimentally demonstrate so far as possible all the different elements of similarity which exist in common with modern mathematical concepts and procedure and to classify them with scientific precision.

It is asserted by many teachers of mathematics that "deductive reasoning" has wide use in a great variety of situations in life. Some psychologists and educators, on the other hand, would have us believe that deductive reasoning is a rare form of mental activity, that "the thinking of the mental world is not done in syllogisms but inductively and in biological terms."

Who is right can only be determined by getting together on common ground, which from the nature of the case must be psychological. There certainly should be no confusion of induction as a mode of inference from observed phenomena and deduction as a mode of application of a generalized proposition based upon certain hypotheses.

Current literature also abounds in loosely stated or poorly chosen expressions of mathematical values such as: "reasoning power," "power of concentration," "ability to analyse" and "accuracy." As a matter of probability, if we were to cross over into psychological territory, we should have to be more precise and translate these ideas and we should find ourselves talking about "habit of reasoning," "habit of concentration," "habit of analysis," "habit of accuracy," "habit of neatness," and "habit of imagination." Mental powers are the product of at least two factors, native capacity and habituation. The former cannot be increased by mental training, the latter is the chief business of education. It is fatal to the validity of any discussion to confuse the two or to forget either. The mathematics teacher thus begins to discover that unless "habits" are actually formed as the result of mathematical instruction, mathematics will not function either as to itself or as to other departments of life, and in such case its claims to such virtues as those suggested are largely invalid, hopes to the contrary notwithstanding.

The case of "interest versus effort," which of course applies to other than mathematical subjects, has been much misunderstood because terms have been loosely defined or their meaning not closely adhered to. It makes a vast difference in its bearing upon the mathematical situation whether "interest" means "entertainment" or "self-directed activity." And there are those who carelessly, certainly we trust not intentionally, confuse the whole subject by viewing it solely from one or the other extreme aspect.

Again there are numerous instances of attacks upon mathematics as a secondary school subject which appear to be based on the assumption that there has been no progress made since the last century in arrangement and treatment of subject matter or in methods of teaching. The extreme formal type of mathematical training is made to stand for the whole field. Either progressive teachers of secondary mathematics must find some adequate means of acquainting the educational world

with the extent and degree of progress made or else they must openly agree that the charges are true and point out that they are directed, not at present accepted standards but at a discarded position no longer regarded as tenable by mathematicians themselves.

Moreover, it is hardly safe to ascribe "moral and spiritual" or "ethical" values to abstractions or the science of abstractions. If the conclusions of mathematics are necessary, there can be no virtuous act in arriving at them, the mind has not "functioned morally or spiritually." And the psychological skeptic inquires somewhat facetiously for the evidence that mathematicians are more ethical or spiritual than their brethren who have not been exposed to the benign influences of mathematical truth.

Further illustrations are unnecessary to demonstrate the imperative need there is for scientific soundness and precision in the choice and use of terms and descriptive language in this critical stage of the foreclosure proceedings that have been instituted against mathematics as a factor in education. The truth of the matter can be approximated much more closely than has yet been done. The student of mathematical pedagogy should use every available means and opportunity for analysis, experimentation, and psychological demonstration toward a genuinely scientific and universally valid solution of this vexing question. All parties to the discussion will rejoice and forget their differences in the presence of results which rest unequivocally upon firm scientific foundations. Unfortunately, much of the controversial dust that beclouds the educational atmosphere will not contribute to that highly desirable end.

The mathematician has had some reputation for habits of exact thinking, at least within the domain of his subject. Let him take heed that he carries over some of those habits when he invades the field of the psychologist and especially when his task is to demonstrate that such habits do function in other fields of mental activity.

CLASSROOM SAYINGS.

From ninth year general science test:

Question: "How could you prove experimentally that there are yeasts in the air?"

Answer: "The proof of yeasts in the air is this, the raising of the air up to the heavens."

THE TEACHING OF ELECTRICAL POTENTIALS IN CELLS OR GENERATORS TO ELEMENTARY STUDENTS.

By MASON E. HUFFORD,

Instructor in Physics, Indiana University.

In the teaching of physics to elementary students, analogies of many kinds suggest themselves for giving a clearer understanding of the laws and principles involved. The use of these analogies is justified since science, and especially physics, is very difficult for many students. One of the most difficult principles met with in the teaching of electricty is the law and application involved in the expression,

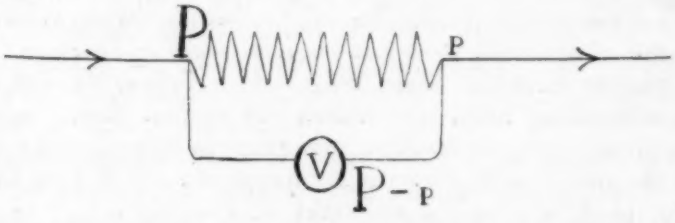
$$Pd = IR - E,$$

where Pd represents the fall of potential across cell terminals, I and R respectively represent the current and resistance of the cell, and E the electromotive force.

After a little study and experimentation, students have a fair understanding of Ohm's law in its simplest form,

$$Pd = IR,$$

and it is easy for them to see that if a voltmeter is connected across the terminals of a plain resistance, say of wire, then the above expression applies. It is very helpful to elementary students to show them that the electrical pressures are exactly like those at the ends of a water pipe, in which resistance to flow is met with, and to illustrate this by letters P and p, the size of the letter indicating the magnitude of the pressure at the point.



Then current flows from high pressure to low pressure and the voltmeter measures the difference of pressure, Then,

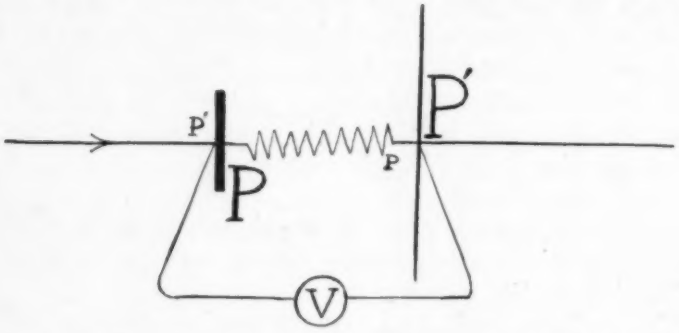
$$P - p = Pd = IR.$$

Now if the voltmeter is connected across terminals which contain a source of electromotive force as well as resistance, as in the case of a voltaic cell, another illustration may represent the potentials.

Here P—p represents the fall of potential due to plain liquid resistance as before. It is positive in algebraic sign and is equal

to IR, R representing the liquid resistance of the cell or generator.

P′, p′ represent the potentials of the electrodes which are produced, in the case of a cell, by chemical action. Then P′ − p′ is the E M F, E of the cell. The algebraic sign is taken negative because the current flows against this difference of potential.



Now when a voltmeter is connected across the terminals of the cell, the reading of the instrument is,

$$Pd = (P-p)-(P'-p')$$

that is,

$$Pd = IR-E$$

It proves, usually, that Pd is negative. This need give the student no difficulty as it may be written negative in the equation with clear meaning.

Now let a source of electric current, say a dynamo, be connected into the circuit of the cell so that I may be made large. Then if the current through the cell has become larger, evidently the fall of potential P − p has become larger in order to force the current through. When $P-p = P'-p'$ then, $Pd = 0$, and the cell neither helps nor hinders the current flow. Indeed, the current I may be made so large that the difference of potential required to send the current through the cell may be larger than the E M F of the cell, that is, $P-p > P'-p'$. In this case Pd is positive and the voltmeter must have its terminals reversed in order to measure the voltage.

If current from an outside generator should be sent through the cell, from positive to negative, then the fall of potential due to the liquid resistance is the same in magnitude as before but reversed in direction so that the potential at the positive terminal is $P = p+p'$ and at the negative $P = P+P'$ so that,

$$Pd = (P-p)+(P'-p').$$

Here again the Pd may be regarded negative since it is in the

same direction as the chemically produced difference of potential.

This treatment of the rise and fall of potential enables the student to see in a concrete way the behavior of electrical pressures in a cell and gives him more to think about and to work with in his future problems in potentials than a mathematical equation.

THE CLIMBING MONKEY.

By WILLIAM F. RIGGE,
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L'Astronomie, in its issue for July, 1917, presents this problem: To one end of a rope, passing over a fixed pulley, a monkey is clinging, while his equal counterpoise is fastened to the other. The monkey now begins to climb up his end of the rope. What happens to the weight at the other end? Does it go up or down or remain stationary?

The weight remains stationary, because whatever the monkey does he cannot change his weight and that is balanced by the counterpoise. Neither a higher or lower position, nor motion of any kind affect weight. Jerky climbing up or down, which introduces acceleration, can have only a passing effect on the counterpoise, because the monkey's acceleration is instantly met by the contrary acceleration of the balancing weight. If the monkey should let go of the rope, drop some distance and catch hold again, the counterpoise would also drop the same distance, but would again become suddenly stationary like the monkey himself at the moment. If he should climb up with sudden and jerky pulls, the weight would be raised momentarily at each effort.

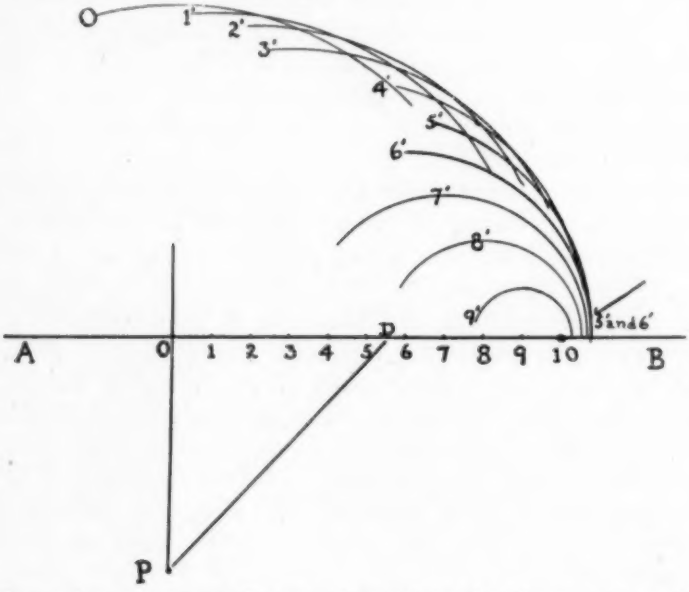
Experiment proved the above explanation to be correct. The works of an old clock, weighing 240 grams, were arranged to wind up a string, which was drawn over the nine-inch pulley of a fine Atwood's machine and tied to an equal counterpoise. When the system was at rest, a thread holding the last wheel in the train was burned and the winding spring allowed to act. The clockwork mounted at the rate of eighty centimeters in a minute, but the counterpoise remained where it was, neither rising nor falling. The same was true when the clockwork descended. Occasional jerkiness caused by the sudden slipping of one turn of the string on another had only momentary effects on the counterpoise.

A GRAPHIC METHOD OF DETERMINING THE CRITICAL ANGLE BY AN APPLICATION OF HUYGHEN'S PRINCIPLE.

By J. K. Robertson,

Queen's University, Kingston, Ontario.

In texts on elementary optics, even in the case of those discussing the subject more from the standpoint of waves than from that of rays, few if any references are made to the cause of total reflection and the physical meaning of the critical angle. That these points can easily be made evident, however, to any student with a clear understanding of Huyghen's principle will be clear from the accompanying diagram.



Waves from a source P are refracted at the plane surface AB, separating two media, the velocity of the waves in the upper medium being assumed to be 1.5 times that in the lower. The lower medium might therefore be glass, the upper air. Suppose, now, we follow a wave-front starting from the source P. At a certain instant this wave-front will have just reached the surface AB at the point O, and a secondary "wavelet" will just be on the point of spreading out from O. After a short interval the wave-front will have reached the point 1, and another wavelet will then be about to start from this point. Still later disturbances will be created at points 2, 3, 4, 5, etc., wavelets spreading out from each of these in succession. To find, now, the new re-

fracted wave-front in the upper medium at any given instant, we apply Huyghen's principle, drawing the position of each wavelet at this instant. For example, in the diagram, the position of wavelets originating from the points 0, 1, 2, 3, 4, 5, 6, 7, 8 and 9 are represented at the instant the original wave-front in the lower medium has just reached the point 10.

The method of drawing these is at once evident. Take point 4 for example. The disturbance from it at the instant under consideration will have travel'ed a distance in the upper medium $= (P_{10}—P_4) \times 1.5$. With point 4 as centre, therefore, and radius equal to this value, a portion of a circle (marked 4^1 in diagram) is described to represent the position of this wavelet. [In the lower medium there will be, of course, a reflected wavelet from this point of radius $P_{10}-P_4$. To avoid confusion, however, no reflected wavelets have been drawn.]

Now a glance at the diagram will show that while there is an enveloping surface for the wavelets from 0, 1, 2, 3, 4 and 5, forming the new refracted wave-front, *there is no real envelope for wavelets from* 6, 7, 8, 9. In other words, for all particles on the surface beyond a point somewhere between points 5 and 6, *no refracted wave-front is possible* because the individual wavelets fall within each other, and reflection alone takes place. It follows further that OPD is the critical angle for these two media. For the purposes of reproduction the points 1, 2, 3, 4, etc., have been taken fairly far apart and it is not possible to locate the position of D very exactly. By means of a more careful diagram, however, the critical angle may be measured directly with a fair degree of accuracy. In the diagram reproduced, the angle OP5 is 40°, OP6 is 45°, while the critical angle as calculated in the ordinary way for an index of 1.5 is 42°. It will be noted, too, that such an estimate of the critical angle can be made *before the student has even heard of the sine law of refraction.*

The writer has found the above treatment useful in a course on light in which physical ideas are emphasized as much as possible, and hopes that it may prove of use to other teachers of this subject.

A ROOF TRUSS FOR THE LABORATORY.

By GEORGE E. THOMPSON,
Ames, Iowa.

It is sometimes desirable, from the standpoint of the student and instructor alike, to have the results of problems in analytical or graphical statics verified experimentally. The following paragraphs state a problem and describe a simple apparatus which may be used to measure the forces acting on the joints of the simple roof truss.

The most complicated problem which can be verified by this device is represented in Figure 1. Snow loads may be represented by weights hung at *b* and *d;* apex load by weight at *c;* wind load by weight at *d*, having its direction determined by a pulley at *f*. The weight of the truss is to be considered as acting equally at *b* and *d* in the case of a symmetrical truss.

The results sought are the vertical reactions at *a* and *e;* the pin pressures at *a* and *e* (both magnitude and direction); and the tension in the tie rod at *e*.

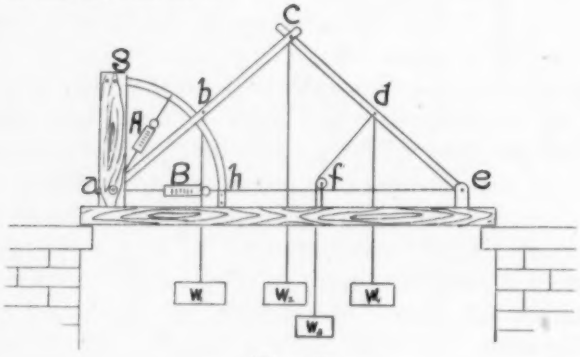


FIG. 1.

The apparatus consists essentially of the roof members *ac* and *ce*, each consisting of two parallel pieces of 1 inch x ¼ inch iron, 85 cm. long, separated 12 cm. and made into a rigid frame by bolts at *a* and *b* (or *d* and *e*). The bolt at *c* acts as a hinge. The arc *gh* constructed of 1 inch x ¼ inch iron and of 45 cm. radius affords points of attachment for balance A at any angle with the horizontal. The pin at *a* works with each end in a hole about one inch in diameter so that the truss cannot get out of alignment. The wooden support is of 2-inch oak. Figure 2 shows an end view.

In order to measure the vertical reaction and the tension in the rod, place balance A vertical and B horizontal and increase the force on each until the pin *a* swings freely at the center of the

hole. The balances will then record the forces sought. To measure the pin pressure at *a* release balance B entirely and move balance A around the arc until the pin *a* swings freely at the center of the hole as before. The angle may be read from graduations on the arc *gh*.

In case the truss is symmetrical, the forces at *e* are found by interchanging the loads at *b* and *d*.

Although there are no principles involved in the use of this apparatus that have not been used in many laboratories before, it is thought that the compactness and portability of this device warrant its description. A roof truss such as described here has been in use in the Iowa State College Physics Laboratory for two years and has proven very satisfactory. The results obtained are remarkably accurate.

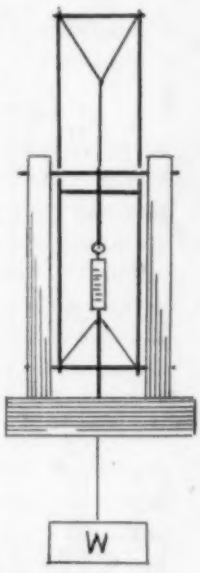


FIG. 2.

A SIMPLE AND EFFICIENT BOYLE'S LAW AND CHARLES' LAW APPARATUS.

By J. GARRETT KEMP,

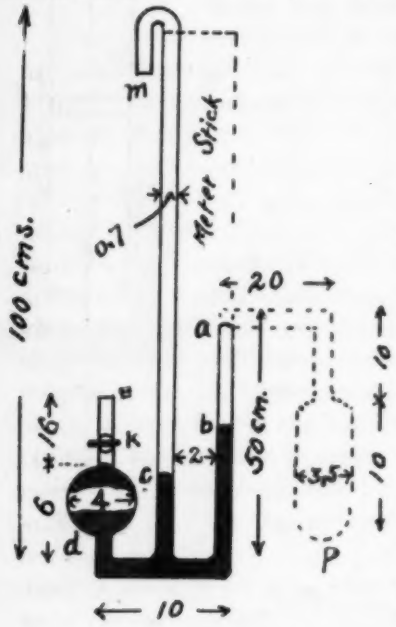
Oklahoma A. and M. College, Stillwater.

A simple and efficient design of a Boyle's law apparatus which will keep the mercury clean for years without changing and have no leaky joints is desired by every teacher of physics in high schools and colleges.

A design, the details of which are given in the diagram, has been in use for the past two years in the physics laboratory of Oklahoma A. and M. College and it has given very satisfactory results. The drawing is not done to scale; however, sufficient dimensions are given to enable a glassblower to make it.

A bicycle tire valve is connected at *e* by means of about 1 1–2 inches of thick walled rubber tubing. A bicycle pump is used to force the mercury out of the bulb, *d*, into the open pressure tube, *c*, and the closed tube, *a*, when the stopcock, *k*, is open. The mercury is forced up the tube, *c*, till it reaches the maximum height without entirely emptying bulb, *d*, of its mercury and then the stopcock, *k*, is closed. The pressure in the bulb, *d*, may be decreased gradually by removing the pump, gently pressing the valve stem and then by turning slightly the stopcock, *k*, to let out air enough to fill the glass tube, *e*, and valve with its tubing.

In this manner a series of very reliable readings of b and c may be obtained.



The apparatus is first filled with dry air by attaching a sulphuric acid drier to m by means of a rubber tube which is at first closed with a pinchcock. An air pump is connected to e and the air exhausted from the entire apparatus. Then by permitting the apparatus to fill with air forced through the drier, dry air takes the place of that which has just been pumped out. By repeating this process several times the tubes will be filled with thoroughly dry air. Now connect the air pump to m and pour mercury into e till it comes just above the stopcock, k. A few strokes of the air pump will draw down the mercury in ab so as to permit some of its air to escape through c out of m to the pump. This operation will permit more mercury to be put into e, when the air is again let into m very slowly until atmospheric pressure is restored in c. The air in ab will now be below atmospheric pressure and it will be the same as atmospheric pressure when the mercury surfaces of b and c are on the same level. In this manner the pressure upon the air in ab may be varied from below atmospheric to nearly two atmospheres.

The dotted outline of the bulb, p, shows the design changed for a Charles' law apparatus.

Separate pieces of apparatus are required for Boyle's law and for Charles' law.

A meter stick secured to a wood strip 125 cms. long and 8 cms. wide by 2.5 cms. thick with a suitable base will do to attach the apparatus to for laboratory work.

If clean mercury is put into this apparatus it must stay clean except for slight oxidation.

There are no troublesome joints to contend with and no impossible packing to be kept in good condition as is the case with many other designs.

THE THIRD LAW OF MOTION AND MR. T. O. PERRINE'S EXPLANATION OF IT.

By N. KUPPUSWAMI,
Training College, Trivandrum, India.

I have always thought that the third law of motion is not an easy thing to be understood by the students at once. But I never thought that anybody could misunderstand it in the way Mr. Perrine has done. See Vol. XVI, No. 1, page 14, of SCHOOL SCIENCE AND MATHEMATICS.

He takes up the familiar problem—the horse pulls the wagon, then the wagon must pull back with an equal force. If so, how is it possible for the wagon to move? The horse pulls the wagon but the wagon must pull back; you do not say which. Therein lies the whole fallacy. The wagon pulls the horse and not itself as Mr. Perrine seems to think. He says, "The wagon is at rest, it tends to stay at rest, it is lazy and does not want to move. *Indeed, it is more than lazy, it actually opposes any force that tries to move it; it strikes back; it reacts against being given further acceleration.*" The italicized statements are not true. They are inconsistent with the first law of motion. The wagon does not exert and never could exert any force to resist its own motion. Only external forces could alter or tend to alter the wagon's state of rest or motion. The on'y external forces that act upon the wagon are the pull of the horse and the friction of the ground. It is so far from the wagon striking back to resist its own motion that it at once responds to the pull of the horse and tries to move and when it tries to move the ground in friction tries to prevent its motion. If the pull of the horse is greater than the friction, the wagon must move irrespective of the fact as to whether it exerts any force upon the horse or not.

Now the question may be put that if the wagon pulls the horse back, how does the horse move forward? Here we have got to consider the external forces that act upon the horse. One is the wagon's pull back and the other is the friction of the ground on the horse. When the horse tries to pull the wagon it kicks against, or rather, presses its foot against the ground, not exactly vertically, with a certain amount of force and the ground reacts upon the horse. If the frictional reaction of the ground on the horse is greater than the pull of the wagon on the horse, the horse must move.

If we consider the horse and the wagon together, the external forces acting upon them are the friction of the ground on the horse and the friction on the wagon in the opposite direction.

When the first becomes greater than the second, the whole thing must move.

The point to be understood in the third law of motion is that when A acts on B, B's action on A is equal and opposite to A's action on B. But B does not and cannot resist the action of A on itself. B's action on A has not the slightest influence on its own motion. In fact, if there are no other forces acting on the bodies A and B—we can conceive of such heavenly bodies—A will move towards B and B towards A, and the action of the one on the other will be exactly equal but opposite in direction.

ECLIPSE SUGGESTIONS.

"From an Oxford Notebook," in remarking on the American Ephemeris maps of the path of the total eclipse of June 8, 1918, makes a suggestion which it may be worth while considering. He says: "Doubtless American and Canadian observers will make good use of this fine opportunity, though their European colleagues may not be able to join them. Several important cities lie on the central line. Would it be possible to organize a large number of observations on the limits of totality, such as Otto Struve arranged (unsuccessfully) for the totally cloudy eclipse of 1887? His idea was to spread out a line of school children across the northern and southern boundaries at intervals of (say) 100 feet, and to get from their testimony the point at which the moon *just* covered the sun. In this way accurate information about the relative diameters and places of the sun and moon might be obtained. Opera-glasses, smoked with camphor, would, of course, be a help if available.'—[*Popular Astronomy.*

NEW ZEALAND STANDARD TIME.

New Zealand has been using Standard Time $11^h\ 30^m$ in advance of Greenwich Time since November, 1868. It is now proposed to change to 12^h in advance of Greenwich mean time. The arguments in favor of the change are about the same as are being used in favor of the Daylight Saving movement in the north. It is not proposed, however, to put the clocks back in winter as is done in the European countries "for many of the advantages referred to would not be gained by an alteration in summer only."

The change was recommended by the council of the Wellington Philosophical Society on November 30, 1916.—[*Popular Astronomy.*

TALC AND SOAPSTONE.

The United States is by far the largest producer and consumer of talc in the world, according to the United States Geological Survey, Department of the Interior. The softness, absorptive capacity, difficult fusibility and solubility, and electric resistance of talc make it one of the most generally useful of all minerals in the arts and industries. Its principal military use is to prevent sore feet among marching soldiers. Only pure ground talc should be used for this purpose. The demand for the "footease" grade of ground talc, which is now extensively used in the army, may be fully supplied in this country. Although the war has stimulated production it has not greatly increased the price.

THE HISTORICAL METHOD IN ELEMENTARY PHYSICS.

By J. R. P. FRENCH,
Pawling School, Pawling, N. Y.

The body of knowledge about natural phenomena that is available for discussion in an elementary physics class today represents an accumulation that began a long while ago and has grown by virtue of the devoted efforts of many individual men to solve particular riddles. Each individual contribution has in due course of time been relegated to its proper place in the whole body of knowledge, and has thereby suffered an inevitable loss of individuality, just as a work of art may suffer by becoming a part of a classified collection, or a literary gem may lose distinction in an anthology.

Now it seems to me a pity that the gem-like quality of these individual contributions to science should be lost; and still more a pity that their human authorship and the sense of their time and place relation should be submerged in their classification. To approach the body of knowledge that exists today as an accomplished entity is to miss much of the romantic human interest that truly attaches to it. Furthermore, it is to convey to the beginner a false impression; or at any rate to deny him a true impression which would be of vital importance to him in constructing his cosmos, in envisioning justly the place of science in what we call culture.

The record of human progress in the knowledge of natural phenomena is just as truly a record and just as truly human as is the record which we are accustomed to call history or the one we call literature. There is no just reason why science or mathematics should be excluded from that once select sodality known as the humanities. But we do exclude science, and deliberately, if we dehumanize it. Open the conventional textbook of elementary physics and you are confronted with a *fait accompli*. Ask a class successfully embarked on the study of this textbook where the knowledge it embodies came from, and you will meet blank stares. There are, perhaps, a few portraits of judiciously selected notables; and the names of Archimedes, Boyle, Newton, *et al.*, occur in the text; but to how many of the class do these tags stand for heroes, in the sense in which Leonidas and Cromwell and Lafayette become heroes in the history class?

On the score of interest only, it is perhaps unnecessary for the physics teacher to tap this vein of romantic human interest. The subject affords sufficient contact with life as we all live it today to

carry it successfully into a vital relation with the pupil's mind; to enable it, as the boys say, to "get by." But on the score of a just conception of the relation of science to the whole record of human achievement, that is to say, to culture, a duty certainly devolves upon the physics teacher. From this aspect it seems to me that a failure to humanize his subject in the historical sense is indeed to "get by," with precisely the implication of the boy-phrase.

I wish to attempt the exposition of a method of presenting certain commonplace material of the physics course in such a way as to emphasize both its human origin and its historical perspective. I shall put my essay into the form of an informal discussion to be held in a class about to enter upon the consideration of that portion of the subject matter which is usually classified as Mechanics of Gases. As I have no notes at hand, I shall be obliged to apologize beforehand for any inaccuracies of historical detail which may appear. I shall use initials to stand for Teacher and Pupil.

T. This is a glass model of an ordinary lift or suction pump, such as you have seen on wells in the country. As I operate the handle, water rises from the vessel; and at the end of the first upward stroke it stands in the pipe, as you can see, some distance above its level in the vessel. To lift water that distance against gravity must require some force; yet nothing has touched the water except the end of the pipe. What did lift the water?

P. Suction.

T. What is suction?

P. (No definite nformation; but the word "vacuum" is tentatively mentioned.)

T. What does vacuum mean?

P. You pump the air out.

T. Then if I pump the air out of anything, water will rush in to take its place?

P. (General agreement.)

T. Now I'll tell you a story. Where is Tuscany?

P. (No response.)

T. Where did the Etruscans live in ancient history?

P. In Italy, north of the Tiber.

T. Yes. Well, their descendants have come to be called Tuscans, and their land Tuscany. It belongs now to the kingdom of Italy; but for a long while it was an independent dukedom. And somewhere about the year 1640 a certain Duke of

Tuscany was having a new well dug in his garden. It was found necessary to go very deep to find water—say forty or fifty feet. When the well was finished, a pump was installed, of the same type as the glass model you have just seen. It was a perfectly good pump; but no amount of pumping would bring the water to the top of the well. It was evident that the pump worked, to a certain extent, because the water was found to be drawn up in the pipe a distance of about thirty feet above its level in the well. But there it stopped, in spite of all that could be done.

The Duke was puzzled, and his curiosity was aroused. He sent to a certain very famous old man who lived in the neighboring city of Pisa, asking him to explain the thing. Do you know anything about Pisa?

P. The leaning tower.

T. Yes. We shall have to discuss later a very interesting experiment that this same old man once performed from the top of that tower. His name was Galileo dei Galilei. Have any of you ever heard of him?

P. (No response.)

T. We usually speak of him simply as Galileo. (Name on board.)

P. Didn't he invent the telescope?

T. Probably not. But he was certainly the first man to use a telescope to advantage in exploring the heavens; and he found out some very remarkable things with its help. He is perhaps most famous as an astronomer; but he was also a great physicist. He was over eighty years old at the time we are speaking of and was almost totally blind; but the Duke knew that he could explain the matter of the pump if anybody could.

He had to admit that he could not. It seems he had already made a number of experiments with pumps himself, but had been unable to account satisfactorily for the circumstance that a pump would raise water only to a certain limited height. The old explanation of the working of a pump was about like what you suggested when I showed you the glass model just now. Scientists were accustomed to say that "Nature abhorred a vacuum," and that therefore water rushed into the pipe to take the place of the air removed by pumping. Why it should stop when it got to a certain height nobody, apparently, had ever tried to explain. All that Galileo could say to the Duke was that evidently "Nature's abhorrence of a vacuum did not extend beyond thirty-four feet."

No doubt if Galileo had been younger he would have kept at this puzzle till he solved it; but the job was finally done by a pupil and particular friend of his named Torricelli. (Name on board.) He went to work on it at Galileo's suggestion; but he did not arrive at the solution till after Galileo's death.

Torricelli reasoned something like this: To lift water against gravity requires force. To lift it thirty-four feet requires a considerable force. If it is simply the vacuum above it that lifts or "sucks" the water up, why should it stop at thirty-four feet? Perhaps it is not the vacuum at all, but something else acting outside and *pushing* it up. If this outside force were definite in amount, then it would naturally lift the water to a definite height—and no higher. Could he demonstrate the existence of any such force?

It occurred to him that mercury, which is nearly fourteen times as heavy as water, ought to be lifted by this force only one-fourteenth as high as water. One fourteenth of thirty-four feet is about thirty inches. So he took a tube, like this, a little more than thirty inches long, and filled it with mercury, just as I am doing. Then holding his finger over the open end he very carefully turned it upside down, and thrust the end beneath the surface of some more mercury in an open dish.

You observe that the mercury falls away a short distance from the top of the tube and then stops. What do you think is left above the mercury?

P. Nothing. A vacuum.

T. Exactly. Physicists commonly speak of it as the Torricellian vacuum. As I put this meter stick alongside the tube you can see that it stands, roughly, about thirty inches from the level of mercury in the dish.

It seems simple enough, this famous experiment of Torricelli's. It is known, by the way, as "Torricelli's Experiment" to every physicist in every country of the world today. It is simple: the remarkable fact about it being only that nobody in the world had ever thought of doing it before. The principle that this simple experiment established was utterly unknown before Torricelli; and yet you must not forget that men began writing down theories about the air two thousand years before Torricelli was born; and that the whole world had for a thousand years been satisfied with the theories advanced by the brilliant philosophers of old Greek and Roman times, and had taught these theories as the truth in all its schools.

Said Torricelli: It is air pressure that holds up the mercury in my tube. It is the *weight of the atmosphere* pressing on the surface of the mercury in the dish. The atmosphere has weight enough to push it up just so far—just as it will push water up only so far in the pipe of a pump.

To make sure, he set his apparatus up in a convenient place and watched it carefully for some days. He found that the mercury did not stay at exactly the same height in the tube all the time; but that one day it would drop a little and the next day perhaps rise again a little.

Over there on the wall is an instrument which is simply a perfected Torricelli tube, with a convenient device for reading the height of the mercury from day to day. What is it called?

P. A barometer.

T. Yes. (Word on board.) Of what use is it?

P. To tell when there will be a storm.

T. Yes; every sea captain since Torricelli's day has been indebted to him for constant valuable assistance. I suppose we might fairly say that Torricelli by that one invention has saved untold human lives and many a valuable cargo. Did Columbus have a barometer when he crossed the Atlantic?

P. No.

T. Did Magellan have one when he sailed around the world?

P. No.

T. Did Drake have one?

P. (Some differences of opinion.)

T. Drake sailed in 1580, or thereabouts. We shall discuss later exactly how a barometer is useful in predicting weather conditions; but for the present I must go on with the story—there is a lot more of it.

Torricelli became satisfied that the air did have weight; and that it was nothing more nor less than air pressure that held up the mercury in his tube. So he published his idea. Do you suppose it came out in some scientific magazine?

P. No. There weren't any.

T. I suspect you are right. Magazines are pretty much modern inventions; and scientific magazines are still more so. I suspect that he wrote letters to his acquaintances and friends among the scholars of Europe; and that they in turn wrote letters to their friends. At any rate, it was not long before many scholars outside of Italy heard of it. One of the men to whom the news came was an enthusiastic young Frenchman named Blaise Pascal. Ever hear of him?

P. (The c'ass has, hav'ng considered Pascal's Principle under the head of Mechanics of Liquids.)

T. Well, Pascal was as enthusiastic about this bit of news as he was about everything else of a scientific nature that came to him; and, as usual, he had a brilliant idea. It was this: if it is true, as Torricelli says, that air pressure holds up his mercury column, then one ought to be able to reduce the height of the column by carrying it to some place higher up in the atmosphere —in other words, where there would be less air overhead to exert pressure.

He proceeded immediately to get the materials and construct a Torricelli tube; and then he carried it from the bottom to the top of the highest building he could find. The mercury column seemed to drop slightly; but he was not satisfied. It so happened that a brother-in-law of his, a man named Perrier, was at that time recruiting his health among the mountains of Auvergne, in southern France—in fact, right beside a particularly high mountain known as the Puy de Dome.

Pascal wrote post-haste to Perrier telling him how to construct a Torricelli tube, and instructing him to carry it from the bottom to the top of the Puy de Dome, and watch the mercury column carefully. Perrier did so; and in an ascent of 3,000 feet the mercury fell some three inches, or more! Which fact, of course, he wrote immediately to Pascal; and Pascal wrote it to Torricelli. Pascal's brilliant idea had been the means of proving beyond any likelihood of doubt the correctness of Torricelli's theory. As a matter of fact, barometers are used today to measure heights as well as to indicate weather conditions. Heights of mountains and "record" heights attained by aeroplanes are all figured from barometer readings. But wouldn't a mercury column like this be a rather clumsy thing for an aviator or a mountain climber to carry with him?

P. They use aneroids.

T. What is an aneroid?

P. (No definite information.)

T. Well, it is another form of barometer, that's all. By derivation the word means simply "without liquid." (Word on board.) It is a dry barometer, not nearly so heavy or clumsy as the mercury instrument, and yet sufficiently accurate. You will have a chance to examine one later. But now I must get on with the story.

Among the men to whom the news of Torricelli's achievement

came was a German named Otto von Guericke. He was burgomaster of the city of Magdeburg. He was much interested in all kinds of science—he made some electrical experiments that we shall consider later on in the year. In fact, he was so fond of experimenting and did so many things that none of his neighbors could understand that he was regarded with some suspicion as being very possibly in league with the devil. I'm afraid he was a little inclined to be a gallery player—at any rate, he seemed to enjoy giving the honest burghers something new to ta k about. They got quite wrought up about him on occasions; and I believe he was once or twice actually brought to trial on the charge of witchcraft. Magdeburg was not the only place where people believed in witches at this time. When was it that the people of Salem, in Massachusetts, began hanging witches?

P. (No information.)

T. Well, it was about 1690—only some thirty years later, you see. When was the Salem colony founded?

P. 1628.

T. Yes. And Galileo died in 1642. Well, to get back to the story, when von Guericke heard of Torricelli's discovery, he proceeded at once to astonish the neighbors with a number of new tricks. First, he built a barometer; but instead of taking a tube thirty inches long and making a mercury barometer, he took one over thirty-four feet long and made a water barometer. The tube was so long that he cut a hole in the roof of his house to let the top end through. Now, as the daily variations of a water barometer are some fourteen times as great as those of a mercury barometer, the water level in his tube moved up and down quite respectable distances. On clear, dry days (when the air is always heaviest) the water level would be above the roof; but on moist or rainy days (when the air is always lightest) it sank below the roof. This gave him a quite characteristic idea and he carved a l'ttle wooden image of a man to float on the top of the water in the tube. In fair weather the image would appear above the roof and enjoy the sunshine; but on the approach of bad weather it would prudently withdraw below the roof, as if seeking shelter. You can imagine what a sensation this caused among the neighbors!

His next move was to design an air pump. That does not sound particularly startling to you; but you must bear in mind that the idea of air as an actual, tangible, material fluid was brand new

in the world. People had no more thought of pumping air (of pumping the air out of a bottle, for instance) than they had of extracting their immortal souls with a pair of forceps. His pump was similar in principle to the one I have here. I shall have to make a diagram to show you how the valves work, as they are not visible. (Diagram on board; and explanation of valve action.)

Now, when von Guericke had built his air pump (the first one, remember, in the world's history) he began thinking of some spectacular thing he might do with it. He finally devised an apparatus similar to this one I have here, only much larger. His hemispheres were about eighteen inches in diameter. Observe that the two hemispheres are ground to fit accurately where they come together; but there is no means of fastening them. Now let us see what happens when I attach the pump and partly exhaust the air. (A few strokes of the pump.)

You see that now when I pick the thing up by this ring the two halves stay together. What makes them?

P. Air pressure.

T. Air pressure where?

P. On the outside.

T. But why didn't they stick before? There was just as much air pressure on the outside before.

P. You have pumped out some of the air that was inside. That makes the pressure less inside than it is outside.

T. That seems reasonable. Blank, come up here and take hold of this other ring. Now, pull. Pull harder. That will do.

Now I'll tell you what von Guericke did. He built his hemispheres; and then before a crowd of the townspeople he attached his air pump, pumped vigorously for a while, and then invited the neighbors to step up and pull the hemispheres apart. Presumably, all the local strong men had a try at it; but they could not budge the thing. So then he invited them to bring on horses. They actually attached sixteen horses—eight on a side—before they got the hemispheres apart. Von Guericke had scored another sensation! We still speak of the trick as the experiment of the Magdeburg Hemispheres.

Do you know how much, in familiar units, the atmosphere actually does press on a given surface? Say in pounds on a square inch? Well, it amounts to just about fifteen pounds to the square inch. Now there are about 1,850 square inches of surface on an average man's body. Take a piece of paper and

figure the total atmospheric pressure which he is subjected to.

P. 27,750 pounds.

T. In other words, nearly fourteen tons. Does that seem possible?

P. No.

T. Nevertheless it is the fact. Why isn't he crushed to a jelly?

P. (No response.)

T. Well, in the first place, the fourteen tons is distributed all over his body, and acts in all sorts of directions, perpendicular to all the body surfaces. Remember Pascal's Principle. Gases press in all directions as well as liquids. So it is not like having the fourteen tons all pressing *down* on the man. Then again, the body has various cavities within it; and these all contain air at atmospheric pressure. In other words the air inside is pressing out just as hard as the air outside is pressing in. There are some interesting practical applications of this matter. Blank, do you know where your Eustachian tubes are?

P. No, sir.

T. Find out before tomorrow, and I'll tell you something interesting about them. Do any of you know what a caisson is?

P. They use them to build tunnels.

T. Yes. How do they work?

P. (No definite information.)

T. Look them up for tomorrow. (Word on board.) You will find something in your book and a lot more in the encyclopedia. Also, if you want some interesting reading, look up a pair of brothers named Montgolfier. (Name on board.) Tomorrow I shall tell you what a certain clever young Irishman did when he heard of von Guericke's air pump. Meanwhile, read what your book has to say about barometers and air pumps. That's all for today.

I have made no attempt to plan the above as an exercise to occupy any precise period of classroom time. I have meant only to extend the narrative sufficiently so that the method might be clear. In practice, interruptions and digressions would probably be more frequent than I have indicated.

As to the sources of the historical or biographical material, I have found particularly useful a "Short History of Natural Science" by Arabella Buckley; and for more extended reading the Britannica.

NOTES ON BIOLOGY TEACHING.

By Benjamin C. Gruenberg,
Julia Richman High School, New York City.

On Teaching Osmosis.

If you are going to teach "osmosis" until all the students know the definition, and then dismiss the topic, the best advice is, *don't.* It isn't worth it. Osmosis should either be taught so that the pupils come to think of diffusion as an integral part of what goes on in and around living things, or it should not be taught at all. It is possible to get a great deal of botanical and zoological knowledge without it.

To introduce the subject of osmosis, it is well to make sure of a clear idea of diffusion. Open a bottle containing acetic acid, ether, alcohol, chloroform, formalin, or some other substance having a distinct odor. Open the gas-cock for a few minutes. When it is evident that the volatile material has reached to some distance from its source, the subject of diffusion may be taken up.

For diffusion in liquids, set up a number of tumblers or wide-mouth bottles with a lump of sugar or some salt in each, and fill with water. These, with vessels of plain water, should stand before the window for a day before they are needed, so that there may be no movements or currents in them from outside disturbance. In class, let fall a drop of red ink into one of the vessels of still water. The diffusion currents of the salt and sugar, and the movement of the ink can be seen; these movements indicate the action of some form of "attraction"—a force that *raises* the sugar (salt) in one case from the bottom of the vessel to the surface of the water, and that in the other case distributes the material (pigment) through a quiet body of water. It must be clear that this "force" is just as real as magnetism or gravity; and we are to show that like other forces this one can *do work.*

To illustrate absorption regardless of diffusion, use a sheet of glue or of gelatin. Wood, leather, blotting paper or a lamp wick behave in much the same way; but the glue and the gelatin are practically homogeneous, whereas the other materials represent structures with visible (microscopic) pores.

"Artificial root hairs" or "cells" may be made of "gold-beaters skin" or of sausage casing (the intestines or bladder of some animal). Many teachers continue to use the egg with

attached tube. Better than any of these is the celloidin bag, since this is practically homogeneous, as the students can see it in process of making; and it gives a simpler situation physically than any of the others.

Use a pure celloidin dissolved in alcohol and ether, free from acetone. Pour a little of the celloidin solution into a four ounce wide-mouth bottle, which must be *clean* and *dry*, and pour back as much as you can into the container, turning the bottle on its axis all the time in order to distribute the celloidin evenly over the glass surface. It is better to get a very thin layer than a thicker one: it is more likely to be of uniform thickness, and therefore less liable to break; and it gives a quicker reaction. Allow the bottle to stand a few minutes, blowing into it from time to time to accelerate the evaporation of the ether and alcohol. Prepare for each bag a two-hole rubber stopper (size No. 4 or No. 5), a thistle tube, a rubber band, and a glass plug to fit the hole in the stopper. There will also be needed the usual mixture of syrup and water, or sugar solution, jars of clean water, and supports.

After all of the ether has evaporated (you can tell this by the odor), add a little water, which will hasten the removal of the alcohol. With a little careful manipulation it is possible to remove the celloidin bag from the bottle without breaking it. Insert the rubber stopper in the neck of the bag and make fast with a few turns of the rubber band. Insert the thistle tube into one of the holes and fill the bag through this. After a little practice, one should be able to complete the whole operation in a few minutes in the presence of the class.

After filling the bag to overflowing, stop the vent with the glass plug, wash the outside of the bag and suspend in jar of clean water. Note the height of the liquid in the thistle tube, and watch the rise of fluid on the inside. If you wish to keep the apparatus set up until the inward diffusion and outward diffusion have reached an equilibrium, it is necessary to use a much longer glass tube. Replace the thistle tube with this before closing vent.

Parallel demonstrations with non-diffusible materials (e. g., starch-paste), salt, sugars of different concentrations, and so on, can be made by different members of the class. Do not overlook the outward diffusion in the presence of the striking inward diffusion of water. The discussion should bring out all the important facts associated with the idea of osmosis. Examples of

diffusion and of osmosis in everyday experience and practical applications should be called for and recorded. In subsequent studies of various physiological processes and plant or animal activities, no opportunity should be lost to point to the facts of diffusion and osmosis.

CREDIT FOR HIGH SCHOOL PUPILS.

An article on this subject is being prepared by a well known writer, and will appear in the columns of this Journal some time before the summer vacation of 1918. Here is given a short bibliography on the subject:

Hyde, *Outlook*, 1902.
Thomas, *Educational Review*, 1905.
Kennedy, *Educational Review*, December, 1906.
Secor, *Educational Review*, May, 1908.
Ladd, *Educational Review*, March, 1909.
Kelly, *Educational Review*, May, 1909.
Judd, *School Review*, December, 1914.
Reudiger, *School Review*, December, 1915.
Judson, *Educational Review*, January, 1917.

CLASSROOM SAYINGS.

The action of an ordinary lift pump is that the water is drawn up and the valve opens and closes and the air pressure jumps the water out.

The motorcycle rider in a motordrome can be almost horizontally without falling because of essentrical force.

A fire burns better on a cold day than on a warm, damp day because the damp air is so heavy that it sinks near the ground and by this a draft cannot get near the fire, while on a cold day the air is lighter and the draft can easily get to the stove.

The three methods of transferring heat are convexion, deduction, and radiation.

A difference in pitch is caused by the difference in length of the windpipe.

A line drawn from any vertex of a circumcised polygon to center of the circle bisects the angle at the vertex.

A Wheatstone bridge is an apparatus to find the resistance of the current of a battery. The Wheatstone bridge in physics resembles the Pythagorean theorem in geometry. Instead of a current going first in a perpendicular direction and then horizontally, it travels in a diagonal way, thus giving much less resistance and use to the battery.

If one should insert a wire in a line with a telegraph wire the current would flow in the same direction. The wires would then be said to be in shunt of each other. The current would divide, and part of it would flow in each wire, and the resistance would not be nearly as great as before the wires were in shunt, and the current could flow swifter and with less resistance.

A boy attempting to prove a theorem by the indirect method, in justifying a statement in proof said, "Two suppositions are permitted in indirect discourse."

An auto skids when going around a corner because of the peterafugal forces which act in all cases of curvilinear motion.

An auto skids in going around a corner because the pavement is so smooth and slippery and the wheel so dry and smooth that the wheel sticks to the pavement.

An auto skids because it has ascertained a common locus in its motion, and changing the direction of force quick tends to move it to one side.

In an ordinary lift pump there is a vacuum when you lift the water. It comes up in this.

When a luminous body gives out light it has two parts, one part to have slightly darkness, which is called penumbra, and the other dark, which is the umbra.

The aneroid barometer consists of a small vacuum, the cover of which is of thin metal and sensitive to pressure.

The dew point is when the temperature is cool below exaggeration.

What are the two kinds of energy? Conneticutt and potential.

The heating of liquids is by the method called conviction.

An ohm is a unit of measure used to measure an ampere of current for one second.

The Leyden jar is the apparatus used to produce an induced current. Lenz was the discoverer of this type of producer, and it was after him that it was called.

Permeability of a substance is where a magnet can make lines of consternation in the substance at one point.

Maganatism is some kind of force that has the power to attract bodies to its surface.

Light is a vibration of the either.

Du Fay said there were two fluids making up electricity—the positive or virtuous and the negative.

Tensity depends upon the amplitude of the strings.

Resonance is a column of air that reinforces the sound that a body makes when passed above it.

The two kinds of energy are potential and carnmetic.

One of the functions of the cerebellum is that it assists in coagulating the movements of the muscles of locomotion.

Trypson acts on facts.

The conciliatiory muscles of the eye cause the suspensory ligament to move the lens.

A filtrable virus is a little insect that will run through the water and filter it.

PLATINUM METALS COMPANY NOT MAKING TESTS FOR GOVERNMENT.

The attention of the United States Geological Survey, Department of the Interior, has been called a number of times to the fact that the Platinum Metals Co. of Philadelphia, Pa., is reported to be testing platinum-bearing materials for the United States Government. In view of the inaccuracy of this statement, it seems well to point out that, though the Geological Survey is now studying the platinum deposits of the United States, no materials supposed to contain platinum have been sent by the Survey to the Platinum Metals Co. for testing. The Geological Survey has made no investigation of the so-called "amagnite process" for saving platinum, though it has received a few samples of the so-called "amagnite" from the company.

Among the advertising matter issued by this company is a copy of a letter addressed to the Geological Survey specialist on platinum by the company itself. Of course any statements made in such a letter carry absolutely no endorsement by a Government official, even if this impression may be given to some readers.

COLUMBUS MEETING OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS, NOVEMBER 30 AND DECEMBER 1, 1917.

A splendid program has been prepared. Go and learn what others are doing. All progressive teachers will be there.

Programs have been mailed. If one fails to reach you, send your name and address to the President, Miss E. Marie Gugle, Assistant Superintendent of Schools, Columbus, Ohio, or to the Secretary, Professor A. W. Cavanaugh, Lewis Institute, Chicago, Ill.

Members from Chicago and the West should join the party leaving Chicago, over the Pennsylvania Railroad, Thanksgiving night, November 29, and arriving in Columbus at seven o'clock Friday morning. Make your reservation for this train through the chairman of the Transportation Committee, Mr. Willis E. Tower, Englewood High School, Chicago.

The meetings will be held at the Ohio State University, whose campus and buildings are unusually attractive at all times, but which has an added feature of having one of the big aviation schools of the country in operation at this time.

THE REPAIR OF BROKEN ELECTRODES.

By N. F. Smith,
Centre College, Danville, Ky.

It frequently happens that the platinum electrodes sealed into the glass of vacuum tubes, Hoffman's apparatus or similar pieces, become broken close to the glass, making a good electrical connection almost impossible. The writer has found that such terminals can be quickly and easily repaired by the use of a small quantity of dental amalgam. The amalgam is mixed with a small quantity of mercury and pressed firmly over the broken terminal, a piece of copper wire being embedded in it while it is soft. The amalgam quickly hardens in place and gives a reliable electrical contact.

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For copies in good condition of Vol. 2, No. 3, May, 1902, we will allow 30c on subscription or 25c cash.

For Vol. 1, No. 2, April, 1901, we will allow 50c.

RESEARCH IN PHYSICS.

Conducted by Homer L. Dodge.

State University of Iowa, Representing the American Physical Society.

It is the object of this department to present to teachers of physics the results of recent research. In so far as is possible, the articles and items will be nontechnical, and it is hoped that they will furnish material which will be of value in the classroom. Suggestions and contributions should be sent to H. L. Dodge, Department of Physics, State University of Iowa, Iowa City, Iowa.

Validity of Ohm's law for High Current Densities.

It has been known from the work of Lecher that Ohm's Law holds up to current densities of 1.4 x 104 amperes per square millimeter. He made use of a silver wire 0.03 mm. in diameter placed in rapidly flowing water. In a recent research conducted by H. F. Traubenberg, an oscillatory circuit was employed, including capacity and self-induction, two micrometer spark-gaps being used, one on either side of the condenser. The wire under investigation was placed as a shunt across one of the spark-gaps, and so currents of very short duration could be dealt with.

In this way it was shown that, within the possible errors of observation, Ohm's Law is valid for current densities up to 10.5 x 104 amperes per square millimeter.

The Latent Heat of Steam.

Mr. T. Carlton-Sutton has recently described a new determination of the latent heat of vaporization of water at 100° C. and one atmosphere pressure. The apparatus is a modified Joly steam calorimeter. A small closed glass bulb suspended from the arm of a balance is cooled to 0° C. in a mercury chilling bath. It is then raised into a heat-insulated chamber at 0° C. and there weighed. The chilling bath is replaced by a steam jacket into which the bulb is lowered. By weighing the bulb in the steam, the mass of the water condensed on it is determined. The bulb is then opened, nearly filled with water, closed again, and the experiment repeated; so that by subtraction the condensation due to the water alone is obtained.

One set of experiments yielded data as follows: Apparent condensation on empty bulb, 0.36502 gm.; on filled bulb, 1.07425 gm.; real difference (after applying all corrections), 0.71181 gm.; mass of water in bulb, 3.8360 gm.; whence, L = 538.89 mean calories. Another set of data gave L = 538.86 and the author claims that the value 538.86 is correct to a few units in the fifth figure.

An Interesting Hygrometer.

A hygrometer may be made based on the fact that certain salts absorb water from the atmosphere in an amount which is closely proportional to the vapor pressure existing at the time. If a filter paper moistened with a solution of P_2O_5 is suspended in a bottle from one arm of a balance and a constant stream of air drawn through the bottle, it is found that the humidity of the air can be determined from the weight of the paper. The apparatus requires calibrating by comparison with a standard method, but this once done, the paper will remain without deterioration for a long time. A convenient form of the instrument can be constructed by hanging the paper from a sensitive spring balance in a tube open at both ends, the air circulation being maintained by a small pilot light in the top of the tube. The spring balance can be graduated to read in vapor pressure directly.

Gravimetric Survey of the United States.

The gravimetric survey of the United States really began in 1890 with the introduction of the Mendenhall half-second invariable pendu-

lum. These pendulums are used to determine the difference in the intensity of gravity at two stations. There are two immediate purposes served in the carrying out of such a survey: first, the collection of data from which more accurate values may be obtained for the flattening of the earth and for the terms of the gravity formula; and, second, to obtain values of the intensity of gravity at laboratories, such values being needed in certain physical and chemical work. Another important use to which the gravimetric survey may be put is in research into the subject of isostasy. The work done in the survey shows that at some depth below sea level (the best value from all geodetic data is believed to be 96 km. for the depth of compensation) the pressure of any unit column is very nearly equal to that of any other unit column. Such being the case, the land masses must be counterbalanced by deficiencies in density of the materials below sea level under the topographic features, and such conditions are found to be much nearer the truth than those based on a rigid earth with the topographic features held up by the strength of the earth's outer material. One of the problems for investigation is the distribution, both horizontally and vertically, of the deficiencies in mass which balance the material above sea level.

NEW COMPOSITION OPAQUE TO X-RAYS.

One of the essential features of a radiological installation is a screen for the tube which effectively limits the field of operation of the rays. Attempts to produce such a screen have been made by incorporating with glass or ebonite certain salts opaque to the rays, but the results obtained have not been satisfactory, as the quantity of salts used has to be strictly limited, since when more than a certain proportion is present the composition obtained is no longer homogeneous and, in the case of certain rubbers, disintegrates with time. A composition has now been found in which the amount of salts can be made very great. It is claimed that the new substance is very opaque to the rays (9 mm. being more opaque than 2 mm. of lead), that it is not brittle, is opaque to light, is relatively light, and is a good insulator.

A method has been developed whereby two clocks or chronometers separated by some 5,000 miles or so may be compared with an error not exceeding 1–100 sec. and with entire elimination of the personal equation. The comparison is made by means of a special arrangement of wireless signals.

An account has appeared of a new element which comes down in the iron group and is supposed to be europium.

CALCIUM CHLORIDE.

Calcium chloride is made from natural brines found in Michigan, Ohio, and West Virginia. As the same brines yield salt and bromine, practically every constituent in them is turned to profit. Calcium chloride is used as the circulating fluid in refrigerating plants, in cement concrete, and in automobile gas-engine water jackets to prevent freezing, and, on account of its power of absorbing moisture, for laying dust on roads, drying gases, vegetables, and fruits, and dehydrating organic liquids. Calcium chloride in solution is especially valuable in automatic-sprinkler systems and in fire buckets.

According to the United States Geological Survey, Department of the Interior, the quantity of calcium chloride produced from natural brines and sold in the United States has recently been about 20,000 short tons a year, valued at $6 to $6.50 a ton. In 1916 the production from natural brines was 26,062 tons, valued at $216,729, equivalent to $8.31 a ton.

PROBLEM DEPARTMENT.

Conducted by J. O. Hassler.

Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions. All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. In selecting solutions for publication we consider* accuracy, completeness, *and* brevity *as essential. Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.*

535. *Proposed by Daniel Kreth, Wellman, Ia.*

Given the distances from the vertices of a triangle ABC to the center of the in-circle, to construct the triangle.

By the Editor.

Let x, y, and z be the distances from the vertices A, B, and C, respectively, to the center, O, of the in-circle. Let r be the radius of the circle and let α, β, γ represent the lengths of the tangents from A, B, and C, respectively, to the circle. We will show that neither an angle, nor a side, nor the radius of the in-circle can be constructed, in general, with ruler and compass.

Since

$$r/x = \sin\tfrac{1}{2}A,\ r/y = \sin\tfrac{1}{2}B,\ \alpha/x = \cos\tfrac{1}{2}A,\ \beta/y = \cos\tfrac{1}{2}B \quad (1)$$

and

$$r/z = \sin\tfrac{1}{2}C = \cos\tfrac{1}{2}(A+B), \quad (2)$$

then

$$r/z = \frac{\alpha\beta - r^2}{xy}. \quad (3)$$

Also

$$\alpha = \sqrt{x^2 - r^2} \text{ and } \beta = \sqrt{y^2 - r^2}. \quad (4)$$

From these equations we obtain the cubic

$$2r^3 + \left(\frac{xy}{z} + \frac{yz}{x} + \frac{zx}{y}\right)r^2 - xyz = 0.$$

Hence, to express r in terms of x, y and z is to solve a cubic, which from the standpoint of geometrical construction means the construction of a cube root—impossible with ruler and compass.

If we choose to eliminate r from the equations (1), (2), (3) and (4) and use instead a function of one of the angles, say $\sin\frac{1}{2}B$, we have

$$2\sin^3\tfrac{1}{2}B + \frac{1}{y}\left(\frac{xy}{z} + \frac{yz}{x} + \frac{zx}{y^2}\right)\sin^2\tfrac{1}{2}B - \frac{xyz}{y^3} = 0,$$

another cubic whose roots are the roots of the first multiplied by $1/y$, which agrees with $r/y = \sin\frac{1}{2}B$.

Finally, by the law of cosines, using (2), we have

$$c = \sqrt{x^2 + y^2 + \frac{2xyr}{z}},$$

which, because of r, involves cube root.

526. *Proposed by R. T. McGregor, Nord, Cal.*

Show that every cube number must be of the form $9n$ or $9n \pm 1$.

I. *Solution by R. M. Mathews, Riverside, Cal., Murray J. Leventhal, New York City, and Nelson L. Roray, Metuchen, N. J.*

Every number N is of one of the forms

$$3m \quad \text{or} \quad 3m \pm 1.$$

If $N = 3m$, $N^3 = 27m = 9(3m) = 9n$.
If $N = 3m \pm 1$, $N^3 = 27m^3 \pm 27m^2 + 9m \pm 1$
$= 9(3m^3 \pm 3m^2 + m) \pm 1 = 9n \pm 1$.

II. *Solution by C. E. Githens, Wheeling, W. Va.*

Every integer, N, has the form $9m$, $9m \pm 1$, $9m \pm 3$, $9m \pm 4$. For criterion, take

$$(9m \pm r)^3 = 9^3m^3 \pm 9^2m^2r^2 \pm 9mr^2 \pm r^3$$
$$= 9(9^2m^3 \pm 9m^2r \pm mr^2) \pm r^3$$
$$= 9M \pm r^3.$$

There are five possible cases:

$N^3 = (9m)^3$,
$N^3 = (9m \pm 1)^3 = 9m \pm 1$,
$N^3 = (9m \pm 2)^3 = 9M \pm 8 = 9(M \pm 1) \pm 1$,
$N^3 = (9m \pm 3)^3 = 9M \pm 27 = 9(M \pm 3)$,
$N^3 = (9m \pm 4)^3 = 9M \pm 64 = 9(M \pm 7) \pm 1$.

In every case N^3 has either the form of 9 times a quantity or 9 times a quantity plus or minus unity.

527. *Proposed by the Editor.*

A man arranges to buy a house for \$5,000 paying \$1,000 down and the remainder in equal monthly installments of \$50. It is agreed that each installment is to pay the accrued interest and the remainder of the installment is to apply on the principal. How many payments will be required to extinguish the debt, with interest at 6 per cent compounded annually?

By the Editor.

According to the conventional rules of investment mathematics (See Skinner: *The Mathematical Theory of Investment*, Ginn & Co.) the amount of 1 at six per cent compound interest, convertible annually is, at the end of the first month $(1.06)^{1/12}$, second month $(1.06)^{1/6}$, etc. It is easy to see that to use 1.005 and $(1.005)^2$ for the amounts at the end of the first and second months respectively is to convert it monthly.

Assuming n = number of years payments must be made, we have the remainder unpaid after each payment expressed by

$$R_1 = 4000(1.06)^{1/12} - 50.$$
$$R_2 = [4000(1.06)^{1/12} - 50](1.06)^{1/12} - 50.$$
$$= 4000(1.06)^{2/12} - 50(1.06)^{1/12} - 50.$$
$$R_3 = 4000(1.06)^{3/12} - 50(1.06)^{2/12} - 50(1.06)^{1/12} - 50.$$
$$R_{12n} = 4000(1.06)^{12n/12} - 50[(1.06)^{(12n-1)/12} + (1.06)^{(12n-2)/12} + \ldots + 1]$$
$$= 4000(1.06)^n - 50\frac{1.06^n - 1}{1.06^{1/12} - 1} = 0.$$
$$\therefore 4000(1.06)^n = 50\frac{1.06^n - 1}{1.06^{1/12} - 1}$$

whence

$$n = -\frac{\log[1 - 80(1.06^{1/12} - 1)]}{\log 1.06}$$

Evaluation of this formula gives $n = 8.47$ years.

There were three incorrect solutions to this problem.

Geometry.

528. *Proposed by Daniel Kreth, Wellman, Ia.*

Construct a triangle, having given one angle, a side opposite to it, and the sum of the other two sides.

I. *Solution by L. E. A. Ling, La Grange, Illinois, and A. E. Breece, Cincinnati, Ohio.*

Given line MB = $b+c$, sum of two sides, also $\angle A$ and the side a opposite to $\angle A$, to construct the triangle ABC.

Construction:

At M draw MK so that $\angle M = \frac{1}{2}$ given $\angle A$.
With B as centre and a as radius cut MK in C.
Draw CA so that $\angle ACM = \angle M$.

Join BC. Triangle ABC is the triangle required.

The proof is obvious.

II. *Remark by Murray J. Leventhal, New York City.*

528 is solved in Schultze and Sevenoak's Plane Geometry, p. 110. The authors, however, fail to mention the possibility of two solutions or no solution, depending on the length of side opposite the given angle.

Correct solutions somewhat similar to the above were also submitted by Katherine S. Arnold, C. E. Githens, Daniel Kreth, R. M. Mathews, and Nelson L. Roray.

529. *Proposed by R. T. McGregor, Nord, Cal.*

The circle whose diameter is the third diagonal of a quadrilateral inscribed in another circle cuts the latter orthogonally.

I. *Solution by (deleted).*

Given 4-gon ABCD inscribed in circle S; also circle T, whose diameter is EF, the third diagonal of ABCD, cutting circle S in H and K, to prove the circle T cuts the circle S orthogonally.

Proof.

Draw HP, diameter of circle S, and HR, diameter of circle T. Draw common chord HK. Join PK and KR.

PKR is a straight line.

$\angle P$ equals $\frac{1}{2}$ half circle HER less half arc HK = half arc KR of circle T.

But $\angle KHR = \frac{1}{2}$ arc KR

$\therefore \quad \angle KHR = \angle P, \qquad (1),$

Similarly, $\quad \angle KHP = \angle R, \qquad (2).$

(1)+(2), $\quad \angle PHR = \angle P + \angle R.$

$\therefore \angle PHR$ is a right angle.

$\therefore$ HR is tangent to circle S,

and PH is tangent to circle T.

$\therefore$ Circle T cuts the circle S orthogonally.

Credit for Solution.

A solution of 523 was received from N. T. Nolan too late for last issue.
Solutions of 516, 520 and 523 were received from Nelson. L. Roray.

PROBLEMS FOR SOLUTION.

Fallacy.

541. *Proposed by the Editor.*

Find the error in the published solution of 529. A correct solution would also be acceptable.

Algebra.

542. *Selected from College Entrance Examinations (Sept., 1917), Advanced Algebra.*

How many numbers between 100 and 1,000 may be formed from 0, 1, 2, 3, 4, 5, 6, no digit being repeated in any number? How many of these are even?

Geometry.

543. *Selected from College Entrance Examinations (Sept., 1917), Elementary Geometry.*

If ABC is a right triangle with the right angle at B, and if D is a point on AC such that AB is the mean proportional between AC and AD, prove that ADB is a right angle.

Trigonometry.

544. *Proposed by Clifford N. Mills, Brookings, So. Dak.*

The angles of a plane triangle form a geometrical progression of which the common ratio is $\frac{1}{2}$. Show that the ratio of the greatest side to the perimeter is $2 \sin \pi/14$.

545. *Proposed by Nelson L. Roray, Metuchen, N. J.*

Express $\sin^2\alpha+\sin^2\beta+\sin^2\gamma-2\sin\alpha\sin\beta\sin\gamma-1$ as the product of four cosines.

SCIENCE QUESTIONS.

Conducted by FRANKLIN T. JONES,
University School, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.*

Questions and Problems for Solution.

266. **Published in May, 1917.** *Please refer to this number and answer question.*

282. *Proposed by W. A. Hedrick, Washington, D. C.*

Why not adopt metric measurements as the *sole* standard of units?

283. *Proposed by R. A. Burtnett, Champaign, Ill.*

A 40-watt lamp burns for one hour immersed in 10 liters of water which is at 10° C. at the time the lamp is turned on. If lamp is 16 per cent efficient as a light, find the second temperature at the end of the hour.

284. *Proposed by William T. Reed, Woodlawn, Pa.*

Do you think it advisable to have all laboratory notes done in the "Lab."?

COLLEGE BOARD CHEMISTRY, JUNE, 1917.

[This paper was criticized by one teacher as "merely a memory test." Does it represent questions of the sort expected on the written examination?—*Editor.*]

Criticize the following:

COLLEGE BOARD GEOGRAPHY, JUNE, 1917.

No extra credit will be given for more than the required number of questions.

GROUP I. (*Answer one question from this group.*)

1. What differences would there be in the climate of the earth if its axis were perpendicular to the plane of its orbit?

2. Draw a diagram showing the relative positions of earth, moon, and sun at the times of spring and neap tides of one lunar month.

GROUP II. (*Answer one question from this group.*)

3. Coral reefs are absent from the shores of the Galapagos Islands, which lie under the equator off the west coast of South America; but they occur around the shores of the Bermuda Islands, 32° north of the equator off the east coast of North America. Explain this peculiarity of distribution.

4. Explain the chief differences between the topography of the ocean floor and the topography of the land. How do near-shore deposits differ from those of the deep sea?

GROUP III. (*Answer two questions from this group.*)

5. The eastern and western sides of Lake Michigan have unlike climates. Which side is the more favorable for fruit raising? Why?

6. Describe two types of barometers. Explain how each works. For what purposes are barometers used?

7. With the accompanying weather map for the morning of December 8, 1916, before you, predict the temperature, wind direction, and state of the sky at Columbus, Ohio (indicated by red star on the map), for the afternoon of the 8th and for the 9th.

GROUP IV. (*Answer three questions from this group.*)

8. In what different ways are lakes commonly produced? Name an example of each kind of lake. Through what processes do lakes usually become extinct?

9. How are alluvial fans formed? In what part of the United States are they most common? Why? What use does man make of them?

10. Describe three types of soils, each of which is characteristic of a particular region of the United States. Explain the origin of each type, and discuss its value for agriculture.

11. Describe the different types of land forms which you would expect to find in a maturely dissected volcanic region, and explain the processes by which each form is produced.

12. Define ten of the following terms: humus, loam, eolian deposit, cumulus cloud, base-level, moraine, water-table, atoll, playa, till, spit, stalagmite.

Solutions and Answers.

254. *Proposed by W. T. Harlow, Portland, Ore.*

A block weighing 500 lbs. can just be supported on a rough inclined plane by a force of 194 lbs., or it can just support a weight of 400 lbs. suspended by a cord passing over a smooth pulley at the vertex. Find coefficient of friction and the inclination of the plane.

Solved by J. H. Baker, Milwaukee, Wis.; R. W. Boreman, Parkersburg, W. Va.; P. C. Hyde, Newark, N. J.; R. E. Hughes, Joliet, Ill.; J. P. Drake, Emporia, Kans.

Solution by R. E. Hughes, Joliet, Ill.

If there were no friction, it would just support $1/2\,(194+400) = 297$ lbs.

Let L be length of plane, H be height, and A angle with the horizontal, then

$$500H = \text{force, } F \times L$$

or $\sin A = \frac{297}{500}$. Hence $A = 35°26'31.7''$.

According to definition of coefficient of friction (E),

$$E = \frac{400-194}{2} \div 500 = .25.$$

276. *Proposed by John C. Packard, Brookline, Mass.*

Why does the moon appear larger near the horizon than when overhead?

Answer by R. W. Boreman, Parkersburg, W. Va.

Just as the depth of a stream of water seems less and bodies immersed in it magnified by apparently being brought closer, as we shift the eye to make the angle of deviation greater, so the refraction by our atmosphere of the light from the moon when seen near the horizon apparently brings it closer and makes it seem larger than when near the meridian when the angle of deviation is practically negligible.

Also, notwithstanding the fact that the moon is nearly 4,000 miles closer to the observer when on his meridian than when on his horizon, when near the horizon intervening objects give us the impression that the moon is very distant, and this influences our unconscious estimate of its size.

277. *Proposed by W. H. Magill, Westtown, Pa.*

In a Wheatstone bridge the A arm has a resistance of 6 ohms, the R arm 3 ohms, the B arm 3 ohms, the X arm 6 ohms, and the galvanometer is replaced by a resistance of 3 ohms. What is the total resist-

ance between the battery binding posts of the bridge and what current flows through the 3 ohms which replace the galvanometer when an E. M. F. of 9 volts is used?

Solved by J. P. Drake, R. E. Hughes, P. C. Hyde, and W. A. Tippie.

Solution by W. A. Tippie, West Technical High School, Cleveland, Ohio.

No current flows through the 3 ohm coil which replaces the galvanometer because there is no difference of potential between the extremities of the coil. This will always be true, regardless of the E. M. F. used.

Since the bridge is a divided circuit, there will be 9 ohms in each branch and the resistance of two equal resistances in parallel is a half of the resistance of one of them, or 4.5 ohms.

(J. P. Drake verified the problem in the laboratory.)

278. *Comment on Board Physics, June, 1917 (published in October, 1917), by P. C. Hyde, Newark Academy, Newark, N. J.*

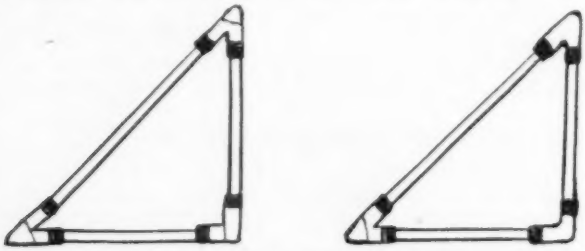
"This examination paper seems decidedly better to me than the one a year ago; but question 4 is decidedly too much *to expect of high school boys.*"

TOOTHPICK GEOMETRY.

By Gladys Doss,

Green City High School, Mo.

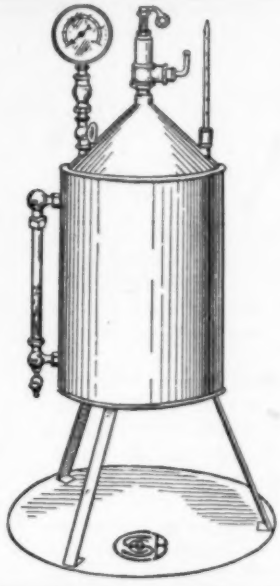
No doubt this sounds curious to the teacher of mathematics but nevertheless it has been very interesting and successful. In undertaking to prepare a way by which geometry might be more easily understood by the beginning student, toothpick geometry, as I have called it, has proved to be very helpful. This so-called work is designed to assist in training the child to careful, accurate, and systematic reasoning in oral work. Would it be convenient to teach history without maps? It is just as inconvenient to teach mathematics without figures.



The materials used in this work are common toothpicks, stickers or labels, and thread. Place the picks in the form desired and fasten them together with the stickers. Use the picks for the heavy lines and thread for the dotted lines. Take for example the proposition, "Two right triangles are congruent if the acute angle and side of one are equal respectively to the acute angle and side of the other," or "If two lines are drawn from a point in a perpendicular cutting off unequal distances at the foot of the perpendicular, the more remote is the greater."

The figures to be made are two triangles in the first proposition and one in the second. This work naturally causes some home study, as the child must become familiar with the theorem in order to know what figures are to be made. They are then brought to class and with books closed each child explains his own figure.

By means of the figures pupils may obtain a double drill which will at the same time strengthen their mathematical ability and increase their accuracy and neatness.



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AIDS IN TEACHING AGRICULTURE.

"The Propagation and Pruning of Plants" is the title of a document recently issued by the States Relations Service, U. S. Department of Agriculture, with the object of helping teachers in the secondary schools to present the subjects in an interesting and effective way to their pupils. The document, which is prepared by Mr. H. P. Barrows, specialist in agricultural education, outlines classroom instruction in both subjects and suggests practicums, projects, and discussions, and gives a complete outline of a demonstration project in this connection, for the renovation of an old orchard. The section on pruning covers principles, the pruning of fruit trees, small fruits, ornamentals, and shade trees, and gives some attention to practical tree surgery. It suggests a number of Farmers' Bulletins which the teacher will find helpful in presenting the subjects.

States Relations Service Document 58, "Types and Breeds of Farm Animals," designed to aid high school teachers in dealing with animal husbandry, contains outlines for classroom instruction relating to cattle, horses, mules, swine, sheep, goats, and poultry.

THE ST. LAWRENCE BASIN.

Great International River and Tributaries Studied and Measured by United States Geological Survey.

The St. Lawrence River system is international, and new questions arise almost every year with respect to the proper division of authority over and the use of this great source of water. A report recently issued by the United States Geological Survey, Department of the Interior, entitled "Surface Water Supply of St. Lawrence River Basin, 1914" (Water-Supply Paper 384), by W. G. Hoyt, A. H. Horton, C. C. Covert, and C. H. Pierce, gives the results of measurements of stream flow made in the St. Lawrence River Basin during the year 1914. The report includes measurements made on rivers emptying into the St. Lawrence by way of Lake Champlain and the Richelieu in New York and Vermont.

The diversion of water for the development of power at Niagara has aroused the attention of both the countries interested, and another question quite as important is that of the propriety of permitting the city of Chicago to divert large volumes of water from Lake Michigan through its drainage canal into Illinois River. The prospective decrease in the depth of navigable waterways, especially those between Lakes Michigan and Huron and between Lakes Huron and Erie, has caused protests to be made by the Canadian authorities.

These two questions illustrate the importance of determining accurately the amount of water supplied to the Great Lakes and St. Lawrence system by the tributaries within the United States, because data of this kind may be of the utmost importance in settling international questions that may at any time arise.

Water-Supply Paper 384 is the latest of a series of similar annual volumes covering measurements on the principal streams of the St. Lawrence basin. The work done in Minnesota, New York, and Vermont was done in cooperation with the State authorities. The report is too technical to be of interest to the general reader but is of special value to engineers. A copy may be obtained on application to the Director of the United States Geological Survey, Washington, D. C.

INDEX TO NORTH AMERICA GEOLOGY.

With the large and continual increase in the literature of every branch of science the need of the workers for indexes is becoming more apparent. For geology, so far as it relates to North America, this need is supplied by the "Bibliography of North American Geology for 1916, with subject index," by J. M. Nickles, just issued by the United States Geological Survey, Department of the Interior, as Bulletin 665. This bulletin consists of two parts; first, an author list giving books and publishers and titles of papers and medium in which published. The authors' names are arranged alphabetically and numbered consecutively for easy reference from the second part, which is an index to the subjects treated by the writers, also arranged alphabetically. There are also supplementary lists of chemical analyses and of minerals, rocks, and geologic formations described. This is the latest of a series of annual bibliographies which at intervals have been cumulated by periods and cover all geologic literature relating to North America. This bibliography and its predecessors, so far as they are still in stock, may be obtained on application to the Director of the United States Geological Survey, Washington, D. C.

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A HISTORY OF ARITHMETIC.

By Fred Molesworth,
Emporia, Kansas.

A History of Arithmetic in the United States, by Dr. W. S. Monroe, Professor of School Administration and Director of the Bureau of Educational Measurements and Standards at the Kansas State Normal School, Emporia, Kansas, was published by the Department of Education at Washington, D. C., as Bulletin No. 10, 1917, in May. The bulletin is a history of arithmetic, with emphasis upon the influence of Warren Colburn in directing the development of arithmetic as a school subject.

At the time of the colonization of America, in the first half of the seventeenth century, arithmetic was not considered essential to a boy's education unless he was to enter commercial life or certain trades. Arithmetic was taught in some of the college preparatory schools. It was not a requirement for entrance to Harvard until 1807. The teaching of arithmetic with reading and writing was made compulsory in Massachusetts first in 1789; also in New Hampshire. While arithmetic was not officially in the schools in this country, it was generally taught in commercial centers or wherever commerce was found. Arithmetic texts by English authors reprinted in this country were used almost exclusively previous to 1800. *A New and Complete System of Arithmetic* by Nicholas Pike in 1788 was the initial step for arithmetic adapted to the needs of the United States. Though Pike was not the author of the first arithmetic in the United States, his book marks the beginning of texts by American authors. The first English text to have an extensive circulation in this country was the *Schoolmaster's Assistant*, by Daboll, first published in 1743. This text was primarily a practical arithmetic. In the period preceding 1800, generally, no book was placed in the hands of the pupil; a book called a cyphering book was used instead. This cyphering book was a blank book made of a quire of paper folded together and sewed. When a problem was completed according to the master's cyphering book—not depending upon whether the master's was correct— it was copied, together with the rule, in the pupil's book.

About 1821 the content of the texts changed abruptly. Arithmetic instruction was modified so as to include mental training. Much of the instruction became oral. This marked the beginning of primary arithmetic and also mental arithmetic, which came to occupy a very important place in the schools later. Pestalozzi has furnished a definite contribution to Colburn's work. "Pestalozzi first conceived the plan; but Colburn realized the plan, popularized it, and rendered it capable of being applied by the humblest mediocrity," according to one of Colburn's contemporaries. *The First Lessons in Arithmetic* was published in 1821. "This book was immediately used in the schools and was more popular than any other arithmetic ever published."

Colburn considered arithmetic to have utilitarian value but he held it to have almost an equal value as mental discipline. He was the first to provide for practice. Before this the arithmetics were very different from his form and from the present form. In Colburn's work the drill exercises stand in the relation of three to one to the practical problems. The pupil is introduced to a topic by means of practical problems. The introduction to number is by means of objects. Skill with numbers is not the prime object; the pupil must have a conception of quantity as well. Colburn introduced the inductive method. There were authors later who believed that they used it but they did not have it as Colburn had it.

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The Journal of Geography

Edited by Professor R. H. Whitbeck of the University of Wisconsin

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Arithmetic was presented in the grades in a series of three books during the period of the formalized Pestalozzian arithmetics. The Pestalozzian formalism consisted in teaching mere words or symbols without giving the learner an appreciation of the real meanings they are intended to represent. In the arithmetic it consisted then of dealing with abstract work, which was very well elaborated, instead of concrete. There was also a higher text for use in academies and colleges. In this period the series by Joseph Ray were the most popular. Class instruction was the rule after 1821; before that time the individual method was used. An assistant had charge of a group and through her assistance made her review of the work. Many practical devices were given; as: a class would work upon the same problem in addition, each member solving a part of it, the solution continuing from one pupil to another. The Herbartian movement and the psychological movement caused an attack upon the disciplinary function of arithmetic. It was believed possible to train the mind in one subject and that this would carry over to other subjects. The Herbartians placed emphasis upon the content of the subject and did much to counteract the emphasis upon the disciplinary function of arithmetical instruction. The final effect was the reduction of the time spent upon arithmetic. The psychological movement resulted in a claim by some educators that the formal discipline theory was completely refuted. "Closely connected with these movements, and partly as a result of them, both educators and the public became more actively critical of the work of the public schools." There has been a reaction against the extreme disciplinary conception of arithmetic and a return to arithmetic as a practical subject.

When the cyphering books were used, arithmetic was taught because it was in demand as a commercial subject. When arithmetic was then taught, though conceded to have but little educational value, it was as a concession to its practical utility. When the colonies became independent and a federal currency established, interest in arithmetic caused its further adoption into the public schools. By the beginning of the nineteenth century arithmetic had a place in the schools but by no means was it of the first importance. Warren Colburn must be given the credit for the placing of arithmetic in the first place of importance of all the school subjects.

USE OF MEAN SEA LEVEL AS THE DATUM FOR ELEVATIONS.

The Secretary of Commerce announces the appearance of a publication of the Coast and Geodetic Survey entitled, "The Use of Mean Sea Level as the Datum for Elevations," prepared by Dr. E. Lester Jones, Superintendent of the Survey. In this pamphlet is discussed the desirability of having a single plane for the whole country, to which all elevations would be referred. This plane is that of mean sea level, which is supposed to be a continuous plane throughout the country from ocean to ocean. For a number of years the Coast and Geodetic Survey has extended a network of elevations of high accuracy, inland from the coasts, with the elevations of its monuments all referred to mean sea level.

The pamphlet, which is called Special Publication No. 41, may be obtained free of charge from the Division of Publications, Department of Commerce, Washington, D. C.

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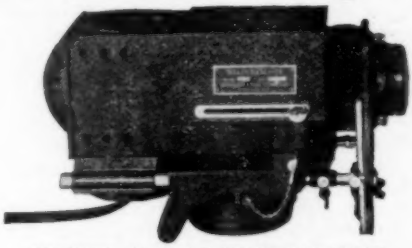

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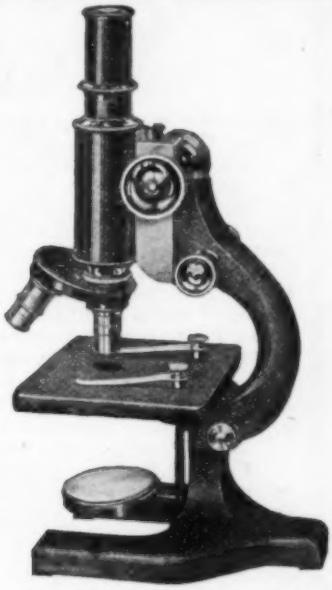

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BOOK REVIEWS.

Projective Geometry, by L. Wayland Dowling, Ph. D., Associate Professor of Mathematics, The University of Wisconsin. Pages xiii+215. 13×19 cm. $2.00. 1917. McGraw-Hill Book Company, Inc., New York.

This volume presents projective geometry from the synthetic point of view for the purpose of developing the power of visualization and of pure geometric analysis for students preparing to teach geometry in the secondary schools, and also to open up a new field to the student familiar with analytic processes. As it presupposes only a knowledge of elementary geometry and a slight knowledge of trigonometry, it may be studied with profit by many teachers of secondary mathematics who cannot avail themselves of the benefit of a course of lectures at the university.

H. E. C.

Infinitesimal Calculus, by F. S. Carey, Professor in the University of Liverpool. Pages xiii+144. 14.5×22.5 cm. $1.80. 1917. Longmans, Green & Co., New York.

"The Infinitesimal Calculus cannot be learned either by memory or by mimicry—it needs judgment and reflection; but if studied in the right spirit it may, by strengthening these qualities of mind, fulfill one of the most valuable aims of education." This sentence in the preface may be the keynote of the author's plan in the development of this subject. The fundamental ideas are explained at great length, and in a most clear and interesting manner. It is a book to be read and re-read by the student, and should give him a complete understanding of the subject. The ideas of range and sequence, usually reserved for books of a more advanced character, are introduced at the beginning and used throughout, but with such clear explanations and illustrations they should aid the student in grasping the fundamental conception of a differential coefficient. This section does not deal with the definite integral, though the last three chapters discuss inverse differentiation and its application in finding areas, volumes, and moments. There is a large number of exercises and practical problems. H. E. C.

Development of Arithmetic as a School Subject, by Walter S. Monroe, Professor of School Administration, Kansas State Normal School. Pages 170. 15×23 cm. Paper. 20 cents. Bulletin, 1917, No. 10, Bureau of Education.

Copies of this publication may be procured from the Superintendent of Documents, Government Printing Office, Washington, D. C. It gives a most interesting history of arithmetic in the schools of the United States, which will aid teachers and superintendents of schools in reorganizing the curriculum of elementary and secondary schools.

The first part covers the period from the beginning of the colonies up to 1821, giving details of the place of arithmetic in colonial education, the subject matter of arithmetic before 1821, and the cyphering book method of teaching arithmetic. The second part, the work of Warren Coburn, describes his relation to Pestalozzi, his arithmetics, and the most significant features of his method in teaching arithmetic. The third part deals with arithmetic as a mental discipline, formalized Pestalozzian arithmetics, teaching arithmetic by devices and drill, and recent tendencies and developments. H. E. C.

Arithmetic Tests and Studies in the Pyschology of Arithmetic, by George S. Counts, Professor of Education in Delaware College. Pages 125. 17×24 cm. Paper. 75 cents. Postage extra. Weight 11 oz. 1917. The University of Chicago Press.

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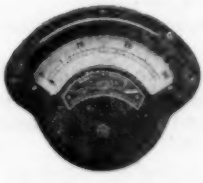

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A Plan for the Teaching of General Zoology—Robert W. Hegner 763
An Explanation of the Practical Side of Baking Powder Manufacture—Its Chemistry—Its Arithmetic—Jessie F. Caplin 774
The Place and Value of General Science—E. A. Stewart 777
Louisiana and Texas Furnish Most of Sulphur 783
Proofs of the Addition and Subtraction Formulas by Means of Ptoleny's Theorem—Albert Babbitt 784
First-Year Mathematics for High Schools—C. B. Walsh 787
Practical Pupil Work with Yeasts and Bacteria—Henry R. Hubbard 795
Announcement 801
The Value of a Science Club in Secondary Schools—Neil E. Gordon 802
Aims and Methods of Project Work in Secondary Agriculture—C. H. Lane 805
Commercial and Industrial Demands on the Chemistry of Tomorrow—B. J. Rivett 810
Some Reflections on the Current Discussion of Secondary Mathematics—Walter H. Wood 815
The Teaching of Electrical Potentials in Cells or Generators to Elementary Students—Mason E. Hufford 819
The Climbing Monkey—William F. Rigge 821
A Graphic Method of Determining the Critical Angle by Application of Huyghen's Principle—J. K. Robertson 822
A Roof Truss for the Laboratory—George E. Thompson 824
A Simple and Efficient Boyle's Law and Charles' Law Apparatus—J. G. Kemp 825
The Third Law of Motion and Mr. L. O. Perrine's Explanations of It—N. Kuppuswami 827
Eclipse Suggestions—Popular Astronomy 828
The Historical Method in Elementary Physics—J. R. P. French 829
Notes on Biology Teaching—Benjamin C. Gruenberg 838
Credit for High School Pupils 840
Classroom Sayings 840
Platinum Metals Company Not Making Test for Government—U. S. Geological Survey 841
Columbus Meeting of the Central Association of Science and Mathematics Teachers 842
The Repair of Broken Electrodes—N. F. Smith 842
Attention 842
Research in Physics—Homer L. Dodge 843
Calcium Chloride 844
Problem Department—J. O. Hassler 845
Science Questions—Franklin T. Jones 848
Toothpick Geometry—Gladys Doss 850
Large Sulphur Reserves 851
Aids in Teaching Agriculture—U. S. Dept. of Agriculture 851
The St. Lawrence Basin—U. S. Geol. Survey 852
Index to North America Geology—U. S. Geol. Survey 852
A History of Arithmetic—Fred Molesworth 854
Use of Mean Sea Level at the Datum for Elevations—Coast and Geodetic Survey 856
Book Reviews 858

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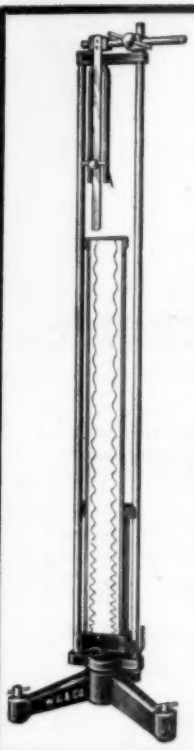

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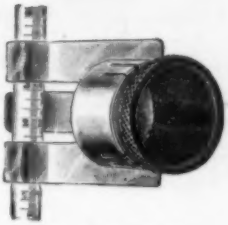

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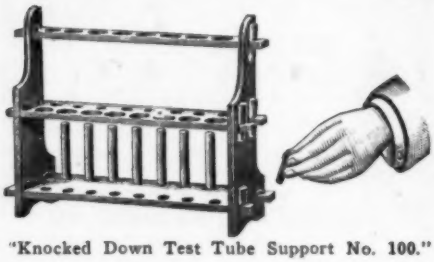

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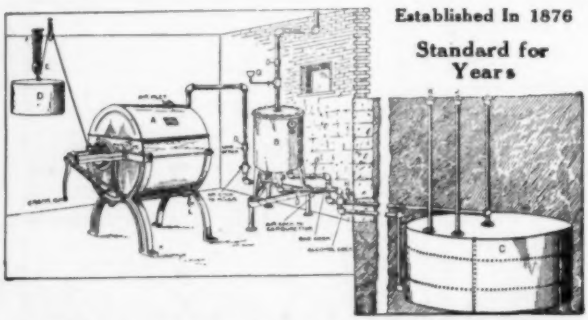

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